CALS TEST NETWORK

CTN Test Report
92-010

Test Report: Phase III Computer-Assisted Data Acceptance

26 May 1992

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TEST REPORT:
PHASE III
COMPUTER-ASSISTED DATA ACCEPTANCE

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Prepared by:

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EXECUTIVE SUMMARY

Army PM JCALS, under the direction of the CALS Test Network Office (CTNO), has developed Computer-assisted Data Acceptance (CADA) procedures for automating the acceptance of CALS raster, Type I, data. The objective of these procedures is to reduce the labor requirements of the currently used manual quality assurance (QA) procedures. Effective implementation of the CADA procedures depends on the use of reliable image quality analysis and identification recognition techniques and tools. This report presents the results of testing these techniques and tools on a large base of CALS digital data. The tests were conducted at the Army CTN test bed, within the CALS Technology Center (CTC) of Army PM JCALS, Fort Monmouth, NJ.

The initial step in this test effort was to develop suites of test data for both image and identification recognition techniques testing. For image quality testing, two different suites of test data were used. One suite (Image Data Set 1) represented the format and quality of CALS contractor procured data. The second set (Image Data Set 2) consisted of a representative subset from some 5,000 engineering drawings obtained from the Army and Air Force DSREDS and EDCARS repository sites. For identification recognition, three different sets of test data were used. ID Data Set 1 was sent to the selected neural network vendors to test their products at their sites. ID Data Set 2 was a larger and different set of DSREDS/EDCARS test data that was used to test the vendors' recognition engines independently at the Army CTN test bed. ID Data Set 3 was developed to test the vendors' recognition algorithms on a suite of test data that closely represented good quality data expected to be procured from CALS contractors in the future.

A number of image quality analysis techniques were tested, including run length ratio, orphan analysis, approximate black and white orphan ratios, peak tile noise, fill factor/compression ratio ranges, border clipping, and verticality analysis. Extensive testing on the two suites of test data resulted in two different combinations of techniques and parameters. One combination established "high quality" criterion for the data expected to be received when procuring CALS data. The second combination was for "low quality" criterion for accepting data that exists today and has been developed over the past 30 to 40 years. Applying the high quality criterion to Image Data Set 1 resulted in a False Accept (FA) rate of 0.68% and a False Reject (FR) rate of 6.18%. (The goal is to accept less than 1% of the bad images in a batch and reject less than 25% of the good images in a batch. All rejected images would be visually inspected by an operator, so all FR would be accepted.) Applying the high quality criterion to Data Set 2, resulted in a FA of 0 % and a FR of good images of 76%. The FR is obviously too high. Applying the low quality criterion to the same set of images resulted in a FA of 0.18% and a FR of 10.53% which is reasonable.

Testing of the identification test data, ID Data Set 1, by the vendors quickly revealed the lack of preprocessing capabilities for the variety of title block and quality of data provided in ID Data Set 1. Four vendors were selected to provide their products for further testing within the Army CTN test bed. Each of these four vendors' products were tested with ID Data Set 2. The average percentage of correctly recognized fields and characters was found to be 28 and 48 per cent respectively. The low percentage of field recognition indicates the inability to segment and remove

lines during the preprocessing stage. The low percentage of character recognition indicates the vendors' tools weakness in recognizing poor quality hand printed characters and/or touching characters. The obvious conclusion was that, for this type data, the preprocessing and recognition capabilities of these products would not be acceptable. The same vendor products were tested with ID Data Set 3. In this case, the average correctly recognized fields and characters were 61% and 74% respectively. One of the vendors was in the 90% range. It is expected that with proper preprocessing/postprocessing of CALS quality data and training on both alpha and numeric characters the correct recognition will be in the upper 90% range.

The recommendations in Section 6 strongly suggest that procurement contracts specify the ANSI Y14.1 and Y14.2M standards be followed closely, in order to implement automated CADA procedures for the acceptance of CALS digital data.

The next steps are to select the vendors products that will be recommended for licensing by the government, integrate these techniques and processing tools, test them on government provided CALS raster Type I data, and deliver them to the Services for field operational testing and evaluation.

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SECTION 1

INTRODUCTION

1.1 BACKGROUND

Data is so important to the logistic support of the Department of Defense's (DoD) weapon systems that every effort must be made to insure that the integrity of the data is maintained, from its procurement through its ultimate use in the field. The procurement contract must clearly specify in the supporting documents (Contract Data Requirements Lists [CDRLs], Data Item Descriptions [DIDs], Statements of Work [SOWs], etc.) the CALS Standards and Specifications, that the contractor is responsible for producing, testing, and delivering quality data and must also define the government's data acceptance requirements at the contractor's site, as well as at the user repository site. The contract may include penalty and incentive clauses relative to receiving quality data, and should address the certification and warranty of the data in order to maintain data integrity in the future.

The data management systems fielded at the Army DSREDS sites, the Air Force EDCARS sites, and the Navy EDMICS sites all have the resources to accept digital data. Manual procedures exist that can be implemented at these sites, yet field testing proved that other means should be employed to reduce the labor intensive effort of viewing each image at one or more workstations. Providing 100% quality assurance of each image by qualified engineering data personnel at the repository may seem to be the best means of data acceptance, but is costly, and perhaps, impractical for the loading of huge amounts of data.

The DoD recognized that the problems of data quality, and the distribution of the data, could best be solved by developing standards for the development and distribution of data in an electronic format. The Computer-Aided Acquisition and Logistic Support (CALS) initiative, introduced in 1985, provided the basis for obtaining quality product and technical publication data, in standard formats on standard media. Industry has been cooperating with the DoD in the development and testing of these standards. As part of the infrastructure modernization effort, the CALS policy office directed the CALS Test Network (CTN) to develop procedures for the acceptance of product and technical publication data in CALS-compliant format. The task was assigned to Army PM JCALS.

The Computer-Assisted Data Acceptance (CADA) procedures developed at the Army CTN CALS test bed, under the auspices of the CALS Technology Center (CTC), for the CALS Test Network Office (CTNO), focus on the acceptance of production (Level III) engineering drawing data. It is assumed that the technical content accuracy has been verified prior to data acceptance and is an issue during data acceptance only if the digitized drawing's readability and reproducibility is impaired. The quality of the accepted digital data must be maintained during the process of conversion, storage, and distribution by the tri-service repositories.

The use of computer-assisted techniques poses certain risks. No technique or combination of techniques will detect where a single dimension, revision letter, or description was hand drawn by using a hard leaded pencil (not conforming to MIL-STDs), and upon being scanned, resulted in missing information. Of course, these risks exist today and qualified inspectors do not always detect these single instance cases. If the techniques are not thoroughly tested, and the results are the false acceptance of poor quality data, which can then be transposed to the repositories' mass optical disk storage media, then this too is risky. If the implementation of the techniques requires excessive repository computer power, or has an impact on the basic mission of the repository, then this is also unwarranted. Not only must the CADA techniques be used with confidence; but, how they are used, by whom they are used, and where they are used, must be considered with care.

The rights to use the techniques is another issue that must be faced. When the integrated techniques have been tested and recommendations made, then the government must obtain license rights to those techniques that are proprietary. The government must have full use of the techniques to implement the CADA procedures in the field.

The automation of the identification data verification involves the application of techniques to "recognize," within the image area, the key identifiers such as drawing numbers, drawing sizes, drawing revisions, etc. The "recognized" ASCII data will then be compared with the CALS key ID header data "keyed in" by an operator.

The usefulness of CADA procedures are highly dependent on the techniques and tools used to implement them. Practical use of the procedures by qualified personnel dictates that they can be used, with confidence, to reject poor quality image and identification data. It is, therefore, essential that the techniques be fully tested in both the laboratory and the field prior to formally releasing them. This report addresses the testing within the laboratory environment at the Army CTN test bed.

1.2 PURPOSE

The purpose of this test phase is, first, to thoroughly test image and identification data (ID) algorithms and tools against quality data that meet the CALS standards.

A second purpose is to evaluate the use of these algorithms and tools, or others, to accept existing data obtained from the Air Force and Army repositories.

1.3 SCOPE

The testing involves obtaining "live" data from DSREDS and EDCARS sites, converting the data to CALS format and then classifying the data for testing.

Both Image and ID testing of the converted "live" data was performed, and the results analyzed and presented in a test report. Image and ID algorithms were used to compare the acceptance of contractor type quality data, with the acceptance of representative existing data.

1.4 APPROACH

The tests defined herein concentrate on testing image and ID techniques for automating the acceptance of quality product data in CALS raster type I format that is expected to be received from a contractor and also to utilize the same techniques, and others, to test the acceptance of existing engineering drawing data obtained from the Army and Air Force repositories (DSREDS and EDCARS respectively).

The approach taken in this test effort for both the image and ID techniques evaluations were:

1. develop a test plan (see Appendix A);

2. identify non-proprietary advanced techniques to be used and develop new ones where necessary for image analysis;

3. select neural network technology for conducting "pre-processing" and "recognition" of the key ID within a suite of engineering drawing test data;

4. develop and classify suites of "quality" image and ID test data;

5. obtain existing DSREDS/EDCARS data, translate them into CALS format, analyze and classify them to build a suite of image and ID test data;

6. conduct image testing of existing and representative "quality" test suites using different combinations of image algorithms and techniques;

7. conduct evaluation of selected vendor neural network techniques via analysis of the suite of existing DSREDS/EDCARS test data and the suite of "representative" contractor derived quality data;

8. document the test results and analyze them; and

9. present the results in a test report.

The image techniques and the neural network vendors' products are described within the body of this report. The test results are summarized in tabular format and the detailed test results are contained in the appendices. The test data were prepared from a cross-section of the data obtained from DSREDS/EDCARS sites and are representative of both poor and good quality existing data. It should be noted that some of the "quality ID test data" was produced by replacing broken lines and removing excessive noise, since this type of data is not expected to be received from the contractor when procuring CALS data.

SECTION 2

TEST DATA REQUIREMENTS FOR CADA TECHNIQUES

2.1 IMAGE TEST DATA PREPARATION AND CLASSIFICATION

The test data for image quality analysis is of two distinct categories. The first category was used for "high quality" testing (i.e., treating the data as if it was delivered by a contractor and applying stringent quality requirements to it). The second category was of "live" data (i.e., existing data from government repositories like DSREDS and EDCARS). The quality requirements for this category were much lower as compared to the first one. The following two subsections describe the preparation and classification effort for the two categories of data.

2.1.1 Image Data Set 1

The tri-services provided the source data that was used to prepare this suite of test data. Aperture cards from the Air Force and the Navy were received and a few were selected for use in building the suite of test data. The CECOM DSREDS site provided original hard copies, which were analyzed, and a number of high quality vellum and mylar drawings were selected that contained a representative sample of sparse and dense drawings that ranged from "A" size through "E" size. The CECOM engineering data personnel utilized their camera and aperture card resources to produce a suite of aperture card test data. The aperture cards included both good and bad data. The bad data cards contained overexposed and underexposed images that ranged from very dark to very light. The result was a data base of some 300 aperture cards of which about one-third were of good quality and about two-thirds were of poor quality.

These aperture cards were then sent to a vendor, who scanned them, without enhancements, to produce digitized data, on magnetic tape, with the images compressed in TIFF CCITT Group IV format. The punched hollerith data, from each aperture card, was stored in the TIFF header of the image file.

After the files were received from the vendor, they were tested for proper CCITT Group IV format of the compressed image data. Of the 300 TIFF files, seven had bit errors in the compressed image data and could not be used for testing. The 293 good files were converted to CALS format for testing purposes, using utility software developed for this purpose. For each file, the software obtained information required for the CALS header, including the punched hollerith data, from the TIFF header, and used it to create the CALS header for that file. The compressed image data in the TIFF file was already in the CCITT Group IV format and needed no further conversion.

The test data was stored on a Sun file server on an Ethernet Local Area Network (LAN). This configuration provided a great deal of flexibility in the test center since the files were accessible on the Sun workstation, and via the LAN, on various PC compatible, and Macintosh, workstations.

One PC compatible image workstation was used to store the entire suite of data in CALS format locally for viewing purposes. Another workstation, a Macintosh, was used to view and make hard copies of the test images.

All of these images were visually examined and classified as acceptable or unacceptable. Since the assumption was that the data obtained from the contractors should be of very high quality, these images were very critically examined and accepted only if they were extremely clear. Out of the 293 images, only 82 were considered acceptable on visual inspection.

2.1.2 Image Data Set 2

To examine the performance of CADA techniques on "live" data, 5,194 engineering drawings were obtained from five different DSREDS/EDCARS sites. The data was received via 9-track tapes in DSREDS/EDCARS format, which was different from the CALS format. Therefore, a conversion from DSREDS/EDCARS format to CALS format was required. An Intergraph machine, obtained from MICOM, was used for this specific purpose, since the utilities for DSREDS to CALS conversion were available on that machine. Each tape was first loaded into the Intergraph and conversion utilities were run. The converted files were then loaded onto a Sun 4 machine, where they were stored on a 1.3 GB hard drive. The Sun 4 was on a local area network allowing the files to be accessed from different machines, such as IBM PCs and Macintoshes.

These images were then visually examined, and a subset of 541 images that provided a good representation of the entire set, were selected. This subset was further examined to classify the images as either acceptable or non-acceptable. The criteria used for acceptance was fairly relaxed. As long as the important areas of a drawing were legible, it was considered acceptable, even if it contained noise and/or faded areas. Out of the 541 images, 527 were deemed acceptable and only 14 unacceptable upon visual inspection.

2.2 ID TEST DATA PREPARATION AND CLASSIFICATION

Three sets of test data were prepared for performing identification recognition analysis and testing. These data sets correspond to the three segments of identification recognition analysis and testing:

1 training and preliminary testing by the candidate identification recognition vendors;

2 testing of candidate vendor products on data that is of the quality found in government repositories today; and

3 testing of candidate vendor products on data that meet CALS standards, and of the quality expected to be delivered by government contractors in the future.

The elements of these data sets were prepared by extracting the title block areas from raster images of engineering drawings, with the use of a raster editor. These sets are representative samples of the various sizes, vendors, and styles of title blocks. Figure 2-1 shows a typical title block. These

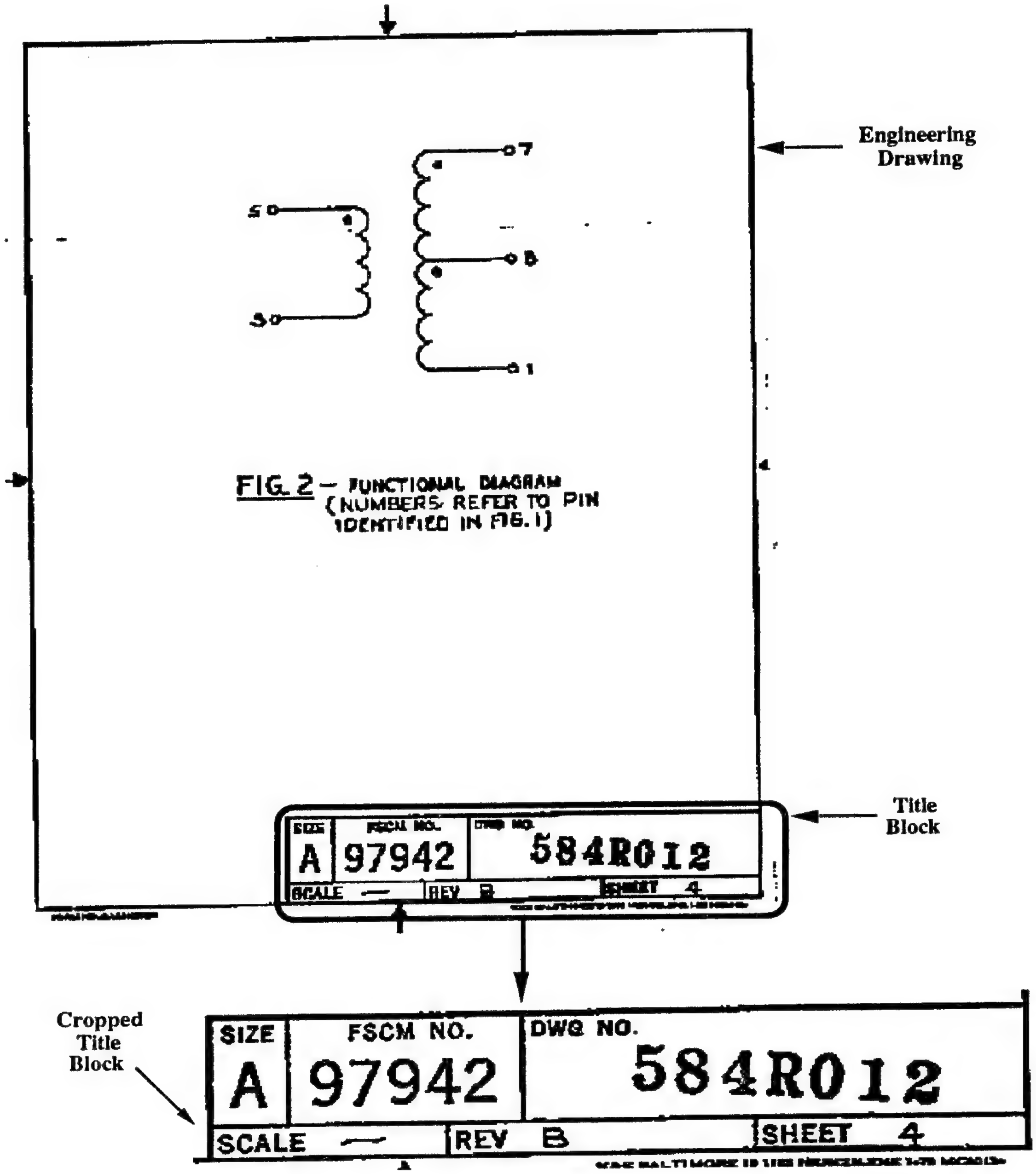

Figure 2-1. Typical Title Block of an Engineering Drawing

title block images were saved in TIFF uncompressed format, prior to their use in the identification recognition analysis and testing process. The details of these test sets are presented in the paragraphs that follow.

2.2.1 ID Data Set 1

Data Set 1 was prepared by classifying data types and sizes for use by the candidate identification recognition vendors. The candidate vendors were to use this set to train their products and to conduct self-tests. The purpose of this test set was to show the candidate vendors the type of data that was to be processed by their product. Examples from this set are shown in Figure 2-2. As the figure shows, the quality ranged from very clear to barely legible.

2.2.2 ID Data Set 2

Data Set 2 was prepared by the Army CTN test bed personnel for testing of candidate vendor products in the test bed. This test set was extracted from engineering data supplied by DSREDS/EDCARS and is considered typical of the data currently stored in the government's repositories. Examples of this data are shown in Figures 2-3. The examples show a range of quality that is present in current repository data along with the non-standard nature of their layouts.

2.2.3 ID Data Set 3

Data Set 3 was prepared by the Army CTN test bed personnel for testing of candidate vendor products in the test bed. This test set was also extracted from engineering data supplied by DSREDS/EDCARS. It was manually enhanced to reflect CALS type, higher quality data that is expected to be delivered by the government contractors in the future. Enhancements included broken line repair, speckle removal, and character separation. Examples of this data are shown in Figure 2-4. The examples show some of the enhancements that were made which simulate the higher quality data that is expected to be delivered in the future.

2.3 DATA QUALITY

The quality of the CALS digital data delivered to the government dictates the amount of quality control (QC) inspection required and directly impacts the cost of accepting the data whether by manual procedures, visual quality assurance (QA), or the use of CADA procedures. Every effort must be made to insure that data quality is emphasized at every stage, from procurement to storage of the data at the receiving repository.

Data quality means different things to different people. Data quality will be discussed herein only as it relates to the use of the techniques and tools to automate the acceptance of quality digital data.

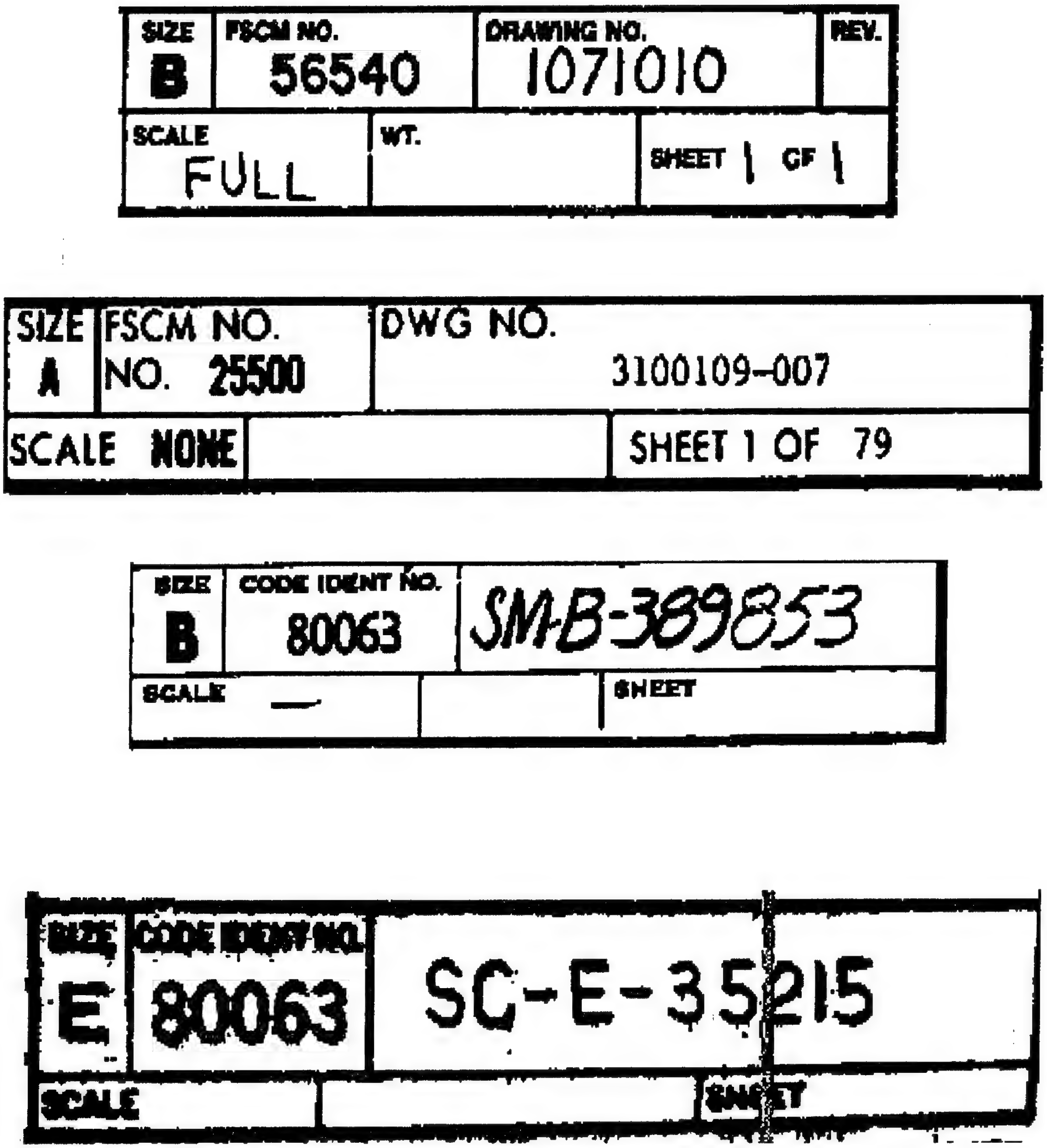

Figure 2-2. Examples from Test Set 1

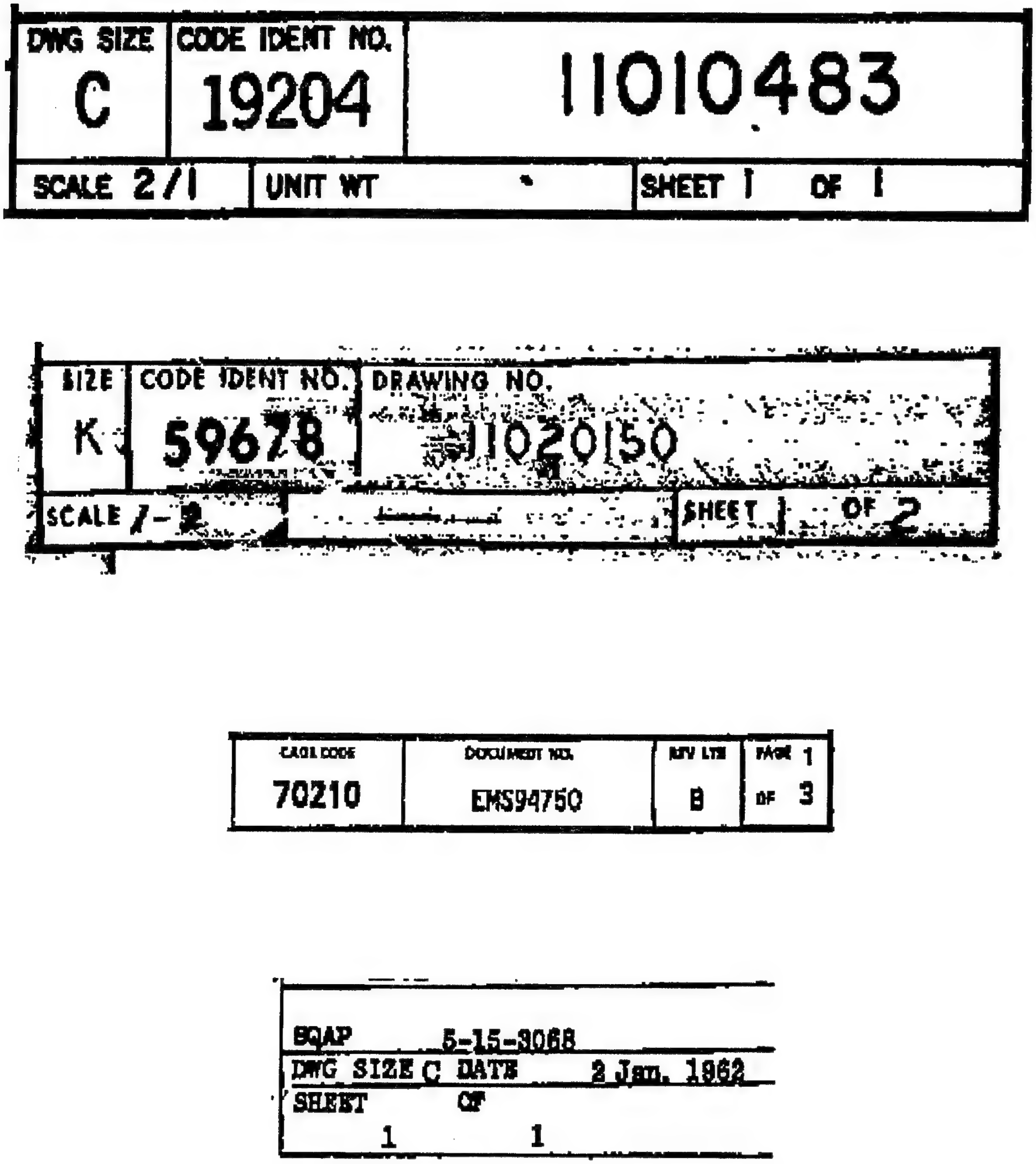

Figure 2-3. Examples of Test Set 2

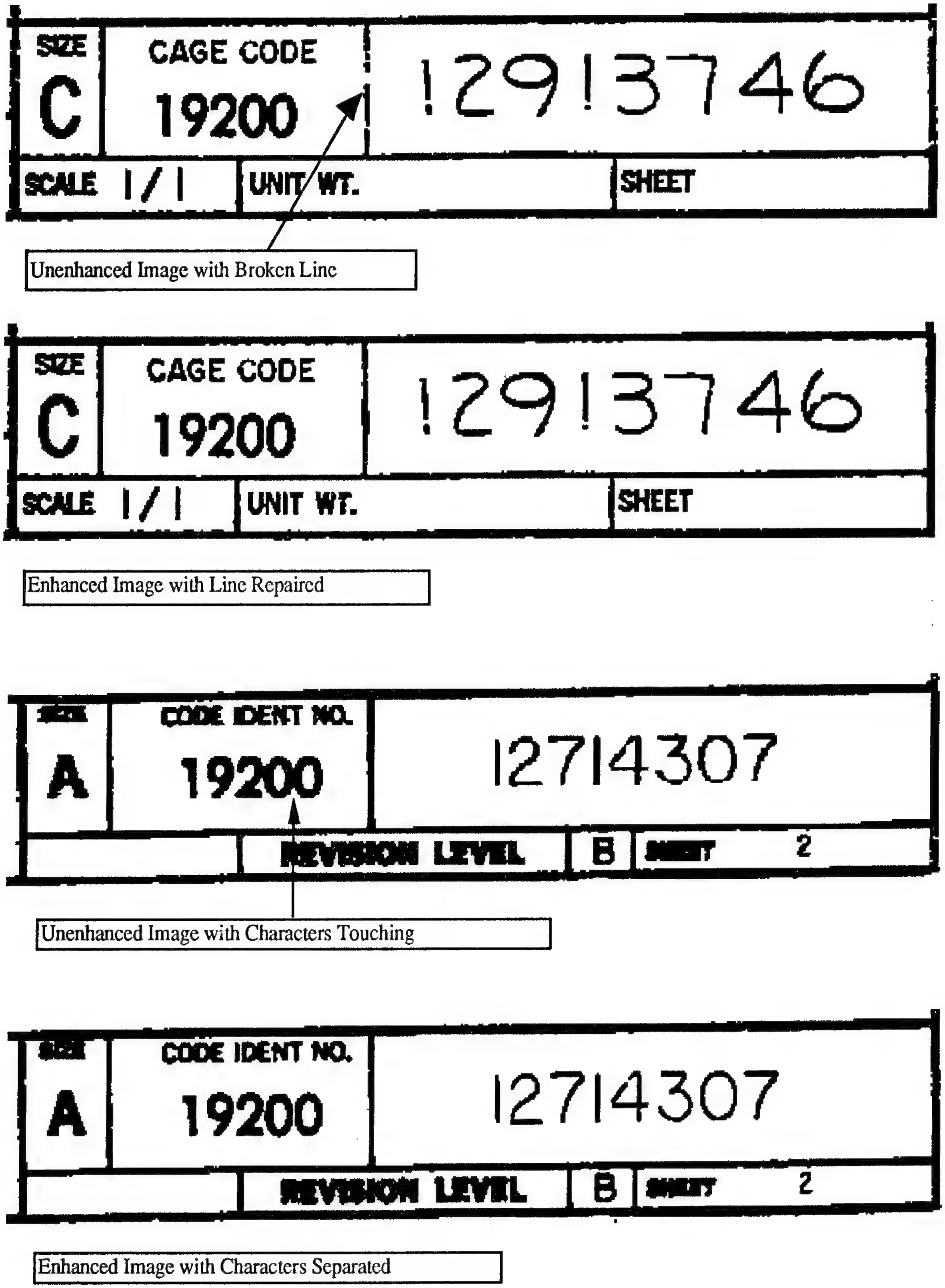

Figure 2-4. Examples from Test Set 3

2.3.1 Definitions

Quality is defined in many ways. Most definitions have been directed towards hard copy or microform documents. MIL-M-9868D is the standard for the acceptance of microfilm engineering documents, and does define some qualities and defects with regard to microfilm image representations. Some of these definitions can be adapted to the application of quality as it relates to raster graphics representations; however, no clear definition of quality for raster images is known to exist.

For purposes of DoD engineering drawings acceptance, quality implies the clarity and fidelity of the digital representation. The clarity and fidelity must be such that, when retrieved from, or reproduced at, the repository, the end user can read, interpret, and measure objects depicted in the drawing image area, and clearly interpret the key ID data within the title block or tabular fields of the drawing. In terms of computer-assisted data acceptance, the quality must be measured objectively in such things as line widths, run lengths, compression, resolution, etc.

2.3.2 Data Quality Issues

The CALS MIL-STD-1840A and MIL-R-28002A define the requirements for the production and delivery of product data in digital format. The format and validity of the deliverable data files, the raster image quality and the quality of the deliverable file header ID are all quality issues that should be considered.

Image quality is an issue primarily when evaluating raster data that was scanned and digitized from hard copy, film, or microfilm sources. The legibility of the raster image may be poor because the source image legibility was poor or because noise was introduced by the digitizing process. The image may be skewed because the source image on microfilm or hard copy was skewed, or because the source image was skewed when it was scanned and digitized. Image quality is not as important an issue when dealing with raster image data files that were generated directly from a CAD system.

A related issue is the degree of compressibility of raster images. Dark images and noisy images both have an excess number of dark pixels which are stored as information by the CCITT Group IV compression. This reduces their compressibility and increases the storage requirements.

The acceptance of engineering drawing data on aperture card media has been in relation to their "legibility and reproducibility." This is very subjective, not to mention that the QA can vary from site to site. The use of computer-assisted data acceptance techniques and tools require more objective guidelines in the preparation and QA of CALS data. This issue must be addressed clearly in the data procurement contract, as well as in the automated acceptance of the data.

SECTION 3

IMAGE QUALITY ANALYSIS AND TESTING

3.1 TEST PROCEDURES

The first step was to prepare and classify the data, which has been described in detail in the previous section. Then a set of iterative steps were followed as described below:

Step 1: Apply a set of techniques (described later) on the set of images being tested and tabulate the numerical indexes corresponding to different techniques.

Step 2: Determine the acceptable ranges for different indexes based on the results of visual inspection. Also determine a combination of different indexes that gives the best results.

Step 3: Based on the ranges established in Step 2, determine which images were falsely accepted or falsely rejected. Visually examine those images and identify peculiar features of those images that may be causing the wrong decisions. Hypothesize a different technique or a different combination of existing techniques that could lower the occurrence of false accepts/rejects.

Step 4: Go back to Step 1 and repeat all the steps till satisfactory results are obtained.

3.2 QUALITY ANALYSIS TECHNIQUES

Individual and combined analysis of a number of raster techniques was performed. The following is a list of all the main techniques used in the test:

- orphan analysis,
- run length analysis,
- fill factor/Compression ratio ranges,
- peak tile noise,
- approximate orphan analysis,
- border clipping, and
- verticality analysis.

The images were processed using evaluation software which was developed to apply the above techniques to CALS format raster image files. No proprietary software packages were used in this test. The image evaluation software was based on the CCITT Group IV decompression software developed by the Lawrence Livermore National Laboratory for the CTN. Code was inserted into the decompression routines to measure quantitative information about the image as it was being decompressed. This was used to collect statistics about each image and to calculate indexes which

described the image quality. These quantitative results were analyzed with respect to the visually classified quality indexes. For reading a magnetic tape in MIL-STD-1840 format, a tool provided by CTN was used. The evaluation software was developed in 'C' language and the user interface was based on OpenWindows.

The following paragraphs discuss each of the techniques.

3.2.1 Orphan Analysis

Orphan analysis is a means of detecting noise data in uncompressed image data. It is the analysis of the frequency of orphan pixels which are found in an image. The basic premise is that pixels of one color (orphans), which are completely surrounded by the opposite color, represent noise data instead of image data.

The orphan parts per million (ppm) is used to determine the amount of noise in an image. Two indexes are used: black orphan ppm and white orphan ppm. Black orphan ppm is the ratio of black orphan pixels to the total white area in the image. White orphan ppm is the ratio of white orphan pixels to the total black area in the image. High orphan ppm indicates a noisy image; while low orphan ppm indicates the opposite; however, it cannot by itself indicate a good quality image. Light images often show low orphan ppm resulting from missing image areas which do not contain orphan pixels.

3.2.2 Run Length Analysis

Run length analysis is a means of detecting noise data in compressed image data. It is the analysis of the distribution of pixel run lengths which have been encoded within a compressed image. The basic premise here, is that if the pixel ran shorter than a minimum pixel width, it would represent noise rather than information. This was derived from the assumption that a normal drawing had line widths of .016 inch or greater as specified in the ANSI Y14.2M-1979 standard for engineering drawing line conventions and lettering. The ratio of the minimum line width to a single pixel width gave the minimum pixel width of that line. In an image with a density of 200 pixels per inch (.005 inch/pixel), the lines would be at least three pixels wide. Consequently, a run length histogram of a normal image would have a distinct peak at or slightly above a run length of three pixels with a sharp cutoff of shorter run lengths. A noisy image would have a peak at a lower run length or no peak at all. The test software computed the number of run lengths in the one-pixel to 10-pixel range and then determined the largest number of run lengths in the four-pixel to 10-pixel range.

The test results showed that, in this suite of test data, good drawings revealed a range of peak run lengths from four to six pixels, but predominantly had a peak run length of five pixels.

The run length ratio was the index used to determine the noise in an image. It was the ratio of the number of one-pixel run lengths to the number of peak run lengths. A high ratio indicated a noisy image; while a low ratio indicated a noise-free image. The following ratios were also tried and the results obtained were similar to the above mentioned ratio: ratio of number of one-pixel and

two-pixel run lengths to the number of peak run lengths, ratio of one-pixel and two-pixel run lengths to the number of peak, peak-minus-one and peak-plus-one run lengths.

3.2.3 Fill Factor/Compression Ratio ranges

This technique analyzed the fill factor (FF) and the compression ratio (CR) of a compressed image. The basic premise was that acceptable images fell into a predictable range of fill factors and compression ratios. This was derived from the assumption that a sparse image (low fill factor) would be highly compressed (high compression ratio) while a busy image (high fill factor) would be compressed to a lesser degree (low compression ratio).

3.2.4 Peak Tile Noise

This technique was used to detect images that were bad only in small areas, such as having small faded portions. Noise indexes based on the entire image may fail to catch such defects. In this technique, the images were divided into 256 pixel X 256 pixel tiles and the noise level (i.e., number of run lengths of one) was computed for each tile. An image was considered good if the maximum noise level for any tile was below an established threshold. This technique performed well in detecting images that were faded in a small area.

3.2.5 Approximate Orphan Ratio

One disadvantage of the orphan analysis technique was that it runs quite slowly. The approximate orphan ratio was yet another ratio, that gave very similar results, and could be computed much faster than an orphan ratio. In a CCITT Group IV compressed image file, pixels in each scan line are coded relative to the pixels in the previous scan line, using one of the three coding modes: horizontal, vertical, or pass mode (see CCITT Blue Book). Each coding mode also has an associated run length. A run length of one in either horizontal or pass mode is a good indication of noise, and gives information similar to the information given by "orphans."

The ratio of run lengths of one in non-vertical mode to the total number of pixels of the opposite color (approximate orphan ratio), was found to work very well and was successfully used in place of exact orphan ratio. Again, the main advantage of using this technique was its speed as compared to orphan analysis. For detecting white noise, a slightly different ratio, that of the number of run lengths of one of white (in any mode) to the total number of black pixels, was found to provide a very close approximation to white orphan ratio.

3.2.6 Border Clipping

While testing DSREDS/EDCARS data, it was observed that many images had a lot of noise along the borders, causing them to be rejected. So, it was decided to ignore 300 pixels (i.e., about an inch and a half) along the four borders of the image while computing various noise indexes. This approach reduced the number of false rejects considerably in the case of DSREDS/EDCARS data.

3.2.7 Verticality Analysis

Verticality analysis was the comparison of the number of vertical modes in a compressed image to the number of both horizontal and pass modes. Since, in a good image, consecutive scan lines would differ only slightly, the number of vertical modes should, therefore, be high as compared to horizontal or pass modes. While this premise was found to be true in general, no significant patterns could be discovered that could be used to accept/reject images with a good confidence level.

3.3 TEST RESULTS

3.3.1 Image Data Set 1 Results

As discussed in section 2.1.1, a set of 293 images were used for "high quality testing" (i.e., testing for quality standards that should be applicable to new CALS data obtained from contractors). For these images, any presence of noise above a certain level was considered to be unacceptable, even if the image was legible (because among other things, noise also causes the compressed image to be larger than necessary, leading to higher storage requirements). Several different techniques, as described in the previous subsection, were tried. As found in the previous test phase, no single technique was considered good enough for obtaining desirable results. Therefore, a combination of different techniques was necessary. The following is the list of techniques that were used in the final combination.

1. **Run length ratio**: This technique was found to be very helpful in detecting noise in images. The acceptable limit for this ratio was set at 14 in this combination.

2. **Approximate black orphan ratio**: This technique was used as a substitute for black orphan ratio for efficiency considerations. It proved very helpful in detecting black speckles, also referred to as "pepper". A cutoff value of 0.02 was used.

3. **Peak tile noise**: Black run lengths of 1 were counted in 256 X 256 tiles and if any tile had a count of more than 156, the image was rejected. This technique proved helpful in detecting defects that were localized to small areas in an image (i.e., fading along an edge.)

4. **Approximate white orphan ratio**: This ratio proved helpful in detecting light images. A cutoff value of .255 was used.

5. **Fill factor**: Images with any worthwhile information were found to have a fill factor of at least two. Otherwise, they were either completely white or completely black.

See Table 3-1 for a summary of these ratios. It was found that by applying a combination of these techniques, most of the bad images were successfully detected. As shown in Table 3-2, only two out of 211 bad images were falsely accepted, which corresponds to a false acceptance rate of less

than 1%. However, about 18 out of 82 good images were falsely rejected, which corresponds to a false reject rate of about 22%. This means that if most of the incoming data were of good quality, about 22% of them would still be rejected and require manual quality assurance, but more than 99% of the bad drawings would be correctly rejected. This represents a significant savings as compared to a 100% manual quality assurance procedure. The detailed results for this set are listed in Appendix B.

Table 3-1. Acceptable ratios for high quality criterion

NO.	RATIO	LIMIT
1	Run length ratio	<14
2	Approximate black orphan ratio	< 0.02
3	Peak tile noise	<156
4	Approximate white orphan ratio	< 0.255
5	Fill factor	>2

Table 3-2. Results for 293 images from Data Set 1

Total no. of images	293
No. of images acceptable on visual inspection	82
No. of images accepted by CADA algorithms	64
No. of images falsely accepted	2
No. of images falsely rejected	18
Percentage of bad images falsely accepted	0.95
Percentage of all images falsely accepted	0.68
Percentage of good images falsely rejected	21.95
Percentage of all images falsely rejected	6.14

3.3.2 Image Data Set 2 Results

As described in Section 2.1.2, a representative set of 541 images were selected from a total of 5,194 DSREDS/EDCARS images. The main aim of testing this set was to see how well the CADA techniques worked with the existing "live" data. The criteria for acceptability in the case of this data were readability and reproducibility of important information areas within an image. The presence of even significant amount of noise or fading were not considered sufficient reasons for rejection if the important parts of a drawing were legible.

The first step was to apply the "high quality" (Set 1) combination of techniques (as described in the previous subsection) to the DSREDS/EDCARS images. Since most of those images would be considered to be of poor quality if they represented new CALS data delivered to the government by a contractor, a very high number of them were rejected by this combination, as summarized in Table 3-3.

Table 3-3. Results on applying "high quality criterion" to Data Set 2

Total no. of images	541
No. of images acceptable on visual inspection	527
No. of images accepted by CADA algorithms	115
No. of images falsely accepted	0
No. of images falsely rejected	410
Percentage of bad images falsely accepted	0
Percentage of all images falsely accepted	0
Percentage of good images falsely rejected	77.80
Percentage of all images falsely rejected	75.79

The next challenge was to find a suitable combination that would accept most of the DSREDS/EDCARS images that were found acceptable on visual inspection, while still rejecting most of the "bad" images. The images were again inspected to identify some features that would be helpful in choosing the right techniques. Among the features observed, the following were the most striking.

1. **Border noise** - Many images had a lot of noise along the borders. It was either due to over-scanning or due to presence of banners along the borders. In many cases, the actual drawing was of a fairly good quality, but the noise along the borders was so overwhelming that it caused the entire image to get a poor quality rating.

2. **Lines of 1-pixel width** - Some images showed presence of thin, only one pixel wide lines. These lines would normally be considered as unacceptable, because they do not conform to ANSI Y14.2M standard for engineering drawings (as discussed in the section on run length analysis). However, due to the relaxed acceptability standards for DSREDS/EDCARS data, many such drawings were considered acceptable.

3. **Broken lines** - Many images had lines that were broken in many places. Again, those images would most likely be rejected if the data were coming from a contractor, but many of them were deemed acceptable under the relaxed standards.

Due to the overwhelming presence of one-pixel width lines, the run length ratio caused a large number of rejects. Therefore,. the acceptable value for this ratio was raised to 30, but the results obtained were still not satisfactory. So, it was decided to discard this technique altogether for this set of data. The approximate white orphan ratio and peak tile noise indexes were also discarded for similar reasons. To eliminate the effect of border noise, border clippings of different sizes (0.5 inch, 1 inch, 1.5 inches) were tried. It was found that clipping 1.5 inches (300 pixels) off the border was the most effective way to eliminate the impact of border noise upon the results.

Eventually, the best results were obtained by using the approximate black orphan ratio with an acceptable value of less than 0.06 and a fill factor with an acceptable value of greater than 0.5 (both of these values were computed after ignoring 1.5 inches along all the four borders). These ratios are shown in Table 3-4. On applying these techniques to the set of 541 DSREDS/EDCARS images, it was determined that out of the 527 visually acceptable images, 57 were falsely rejected and out of 14 bad images, only one was falsely accepted. This meant that out of the total set of 541, 0.18% of the images were falsely accepted and 10.53% were falsely rejected. These results are summarized in Table 3-5. The detailed results are listed in Appendix B.

Table 3-4. Acceptable ratios for "low quality" criterion

NO.	RATIO	LIMIT
1	Approximate orphan ratio (after clipping 1.5 inches along all four borders)	< 0.06
2	Fill Factor (after clipping 1.5 inches along all four borders)	> 0.5

Table 3-5. Results on applying "low quality criterion" to Data Set 2

Total no. of images	541
No. of images acceptable on visual inspection	527
No. of images accepted by CADA algorithms	468
No. of images falsely accepted	1
No. of images falsely rejected	57
Percentage of bad images falsely accepted	7.14
Percentage of all images falsely accepted	0.18
Percentage of good images falsely rejected	10.81
Percentage of all images falsely rejected	10.53

Both the "high quality" and "low quality" techniques were applied to the entire set of 5,194 DSREDS/EDCARS images to get a measure of the resulting number of rejects. Due to the fact that all of the images were not visually examined, the number of false accepts and/or false rejects could not adequately be determined. The main goal was to get a feel for the total number of rejected images. It was found that the "high quality" combination resulted in a rejection rate of 66.71% while the "low quality" combination resulted in a rejection rate of 9.28%. These results are summarized in Tables 3-6 and 3-7.

Table 3-6. Results on applying "high quality criterion" to the entire set of DSREDS/EDCARS images

Total no. of images	5194
No. of images accepted by CADA algorithms	1729
No. of images rejected by CADA algorithms	3465
Percentage of rejects	66.71

Table 3-7. Results on applying "low quality criterion" to the entire set of DSREDS/EDCARS images

Total no. of images	5194
No. of images accepted by CADA algorithms	4753
No. of images rejected by CADA algorithms	441
Percentage of rejects	9.28

3.4 SUMMARY OF TEST RESULTS

The following paragraphs summarize the results of the image quality analysis testing.

1. A combination of five techniques was identified for a high level of quality control standards. Using this combination, one could obtain a false accept (FA) rate of less than 1% and a false reject (FR) rate of 22%. In a typical procurement received from a contractor it would be expected that the good data would exceed 90%. If a 1000 image batch was analyzed for acceptance and there were 100 bad images, the combined techniques as tested would falsely accept one bad image and falsely reject 900 x 0.22 or 20 images. These 20 would be viewed and the rejection overridden.

2. The application of the above techniques to DSREDS/EDCARS data resulted in a very high rejection rate, because most of that data would be considered to be of poor quality if they were new data coming from a contractor. To accept that data, some of the "high quality" techniques had to be dropped, and for others the quality parameters had to substantially relaxed.

   So, the selection of techniques and setting of parameters for image quality depends greatly on the strictness of quality control standards. Due to this reason, the CADA tools for field testing should allow the operators to configure the techniques and parameters, depending on the characteristics of the data and strictness of quality control.

3. The quality analysis techniques can be most effectively used if the quality control is based on objective criteria like conformance to ANSI standards for line widths, absence of noise, lack of fading, etc. If the quality control is subjective and is based more on interpretation of the contents rather than on the criteria mentioned above, these techniques will not give a good performance.

SECTION 4

IDENTIFICATION RECOGNITION ANALYSIS AND TESTING

4.1 TEST PROCEDURES

Identification recognition is the automated process of extraction and recognition of major drawing identification data from engineering drawings. The identification data of each engineering drawing includes: drawing number, sheet number, size, FSCM number, revision number, etc. This section describes the tools selection and test procedures performed for the identification recognition of engineering drawings during this task.

Step 1: The first step to perform the identification recognition test was to select the commercially available tools for this task. The previous phase of the CADA technical report (see *Technical Report, Testing Techniques for Data Acceptance Procedures*, 12 July 1991), listed available tool sets to perform the identification recognition test. Potential candidates were selected from this list. Each interested vendor was given approximately 200 title block images in ID Data Set 1 which was produced and obtained as described in Section 2.2. The vendors were asked to provide their test results based on the provided ID Data Set 1 Data. Four vendors were selected to participate in the tests for steps 2 and 3.

Step 2: The second step in the test process was to test vendors' tools in the Army CTN test bed at the CTC using ID Data Set 2. A specification for the needed Identification Recognition tool was constructed and given to the four vendors. The vendors' tools which were commercially available were allowed to be modified as necessary to tailor their products to meet the given specification. The ID Recognition Requirement Specification is included in Appendix D. The tools provided by the vendors were installed in the CTC facilities in a controlled environment for this part of the test. ID Data Set 2 used in this part of the test was different from ID Data Set 1 that was used in the Step 1 test at vendors' sites. This was done to ensure that the Step 2 test data set had never been used for neural network character recognition training by the vendors. The ID Data Set 2 was produced and obtained as described in Section 2.2.

Step 3: The third step in the test process was to test the same software as in Step 2 on ID Data Set 3. ID Data Set 3 has better image quality then ID Data Set 2. It is expected that the raster image's quality of data procured using the CALS standards will be of higher quality than the existing data of Data Set 2. The objective was to test the vendor software with data that closely parallel data that meet the CALS standards and specifications.

See Sections 4.3 and 4.4 for the analysis and summarization of these tests.

4.2 IDENTIFICATION RECOGNITION TECHNIQUES

Identification recognition techniques described below were used by the tools tested to perform the automated process of extraction and recognition of major drawing identification data from engineering drawings. Currently, the identification process of each engineering drawing is performed manually at the repository sites. If this data can be processed electronically using modern image and character recognition technology, rather than the present labor intensive manual/visual validation method, a time savings can be obtained.

Character recognition is one component of the ID recognition automation solution. To recognize a drawing's identification data, the software must locate the text image field and separate it from other data in the drawing. Next, it must recognize the characters in the field, verify the information and format it to the correct output specifications (see Appendix D). Many different technologies and approaches can be used to achieve this objective. Products provided by various vendors using different technologies were tested and assessed for the feasibility of the CADA identification recognition.

The identification recognition process for the CADA task consists of three independent stages: preprocessing, character recognition, and post recognition validation. These stages are independent functions; yet they are related in the sense that they may affect the other functions' performance and accuracy.

4.2.1 Preprocessing

The first step in the CADA identification recognition process is to look for the title block contained in the raster image of the engineering drawing. This entails locating the title block image area and all of the text fields (and their data) within that area, and then extracting the entire text image for character recognition. Once the appropriate text image data are isolated, they are segmented into characters for recognition. This process of searching for the title block area and the extraction of the appropriate text image data is call preprocessing. The preprocessing function for the ID recognition requires a specialized software tool. No commercial off-the-shelf (COTS) products exist at the present time which can do the preprocessing of the title block area.

The preprocessing function is very similar to the forms processing used in businesses such as the financial community (e.g., IRS forms and check processing), where the data being processed exists within a predetermined area and structure (e.g., checks and IRS 1040s). It is, therefore, relatively easy for the computer to extract the necessary information. Unfortunately, the same technology used in this area encounters many difficulties when it is applied to engineering title block processing, due to the inherent non-standard structure of the data, and the area in which that data resides.

A standard does exist for engineering drawings (ANSI Y14.1-1975, American National Standard for Engineering Drawings and Related Documentation Practices) published by the American Society of Mechanical Engineering. Many of the engineering drawings that were received from the repositories do not follow this standard, especially those drawings completed before the standard

was published. Even many of the drawings that mostly comply with the standard contain minor variations, such as a slight difference in the width and length of the SIZE box. In traditional forms processing, a template is created for each variation. This may not be plausible for engineering drawings due to the many minor variations that exist within the data held at each repository.

The preprocessing depends on the following technologies to extract text image from the title blocks.

4.2.1.1 Line Tracing

In the line tracing method, the procedure follows the pixel lines horizontally and vertically. The positions of the text boxes are calculated by the intersection of horizontal and vertical lines. Once the text boxes are located, the text image in each box can be identified by the histogram of the number of pixels. This approach has trouble with broken lines, therefore, line enhancement algorithms are needed to identify the text boxes in poor quality drawings.

4.2.1.2 Corner Matching

This procedure locates all the matching corners of a box (i.e., it must locate the normal four corners of a box before the area can be identified as a box). Because line tracing is not involved, this method does not have the problem of broken lines in the recognition process. However, this approach is very sensitive to the objects around and adjacent to the corners it attempts to find, therefore, may report false corners. It will also miss corners if the image is tilted or askew.

4.2.1.3 Structure Recognition

Structure recognition uses neural network technology to recognize the position and shape of the boxes in the title area of engineering drawings. A separate neural network can be trained to recognize the pattern of the title block. Each field within the title block can then be recognized and labeled by the network, and text information extracted according to field identification. Obviously, this method can provide a more flexible and tolerant system to accommodate the minor variations in the title block formats. However, additional neural network training would be needed to recognize any major pattern change in that area.

4.2.1.4 Pure Text Extraction

This approach ignores all forms structure, and only recognizes and extracts all text images in the input data. After each field is recognized, it needs to be identified and correlated based on the content of the recognized word. Here the problem is that the correlation and identification processes can be erroneous and ambiguous. For example, the size of the drawing may be identified only by a field name (SIZE); that particular field normally contains a single alpha character (e.g., B). However, there is no guarantee that the recognized field in this case is the SIZE field, because there may be other single character fields on the drawing. Because the structure information is not considered during extraction, as is evident from the previous example, this method is not completely reliable.

4.2.2 Character Recognition

The accuracy of character recognition technology has improved from Optical Character Recognition (OCR) to Intelligent Character Recognition (ICR). OCR techniques rely on one or two rule-based methods for reading machine printed characters: template matching or feature extraction (by fonts), while ICR uses trained neural networks which are capable of recognizing handwritten and hand-printed alphanumerics. It has been concluded in the previous CADA technical report (*Technical Report, Testing Techniques for Data Acceptance Procedures*, 12 July 1990) that OCR technology will not produce enough accuracy in recognizing hand-printed engineering drawing data for the CADA ID recognition. The selection of vendor products for the character recognition engine of this test was focused on only the products using ICR techniques.

4.2.2.1 Neural Network Technology

All ICR technologies are based upon neural network technology. The accuracy of a neural network is very much dependent upon the training that the neural network receives, and the target objects to be recognized. For example, some neural networks are trained to recognize handwritten zip codes, while others are trained to recognize hand-printed capital letter characters. These two networks cannot be interchanged because the accuracy of the neural network decreases if the target object does not belong to the particular category for which it was trained. A well trained character recognition engine can separate and distinguish similar characters, such as the difference between "5" and "S" in a manner similar to the human brain. In the case of characters that look exactly alike, such as "0" (zero) and the letter "O," there is no way for the neural network to distinguish these without further context information. The postprocessing stage was designed precisely for such instances.

Most vendors' neural networks were originally trained to recognize handwritten characters. The input for these networks' training basically came from the National Institute of Standards and Technology (NIST) test and training data, plus each vendor's own sources of handwritten characters. In the future, neural network training for the recognition of hand-printed characters may need to be enhanced (for any selected vendor's product) to create a fully reliable production version of the engine for CADA at future test sites. Some of the selected vendors have started to incorporate such additional preliminary handwritten character training into the neural networks that were delivered for the tests in this report.

4.2.2.2 Character Image Segmentation

Neural network algorithms have proven useful for the recognition of individual, segmented characters. However, their recognition accuracy has been limited by the accuracy of the underlying segmentation algorithm. Segmentation is the method to cut and separate the text image of each individual character in a string for recognition. Obviously, it is a very difficult task for the computer to decide where the start and end points of a character are, especially when the characters touch each other, or are connected to a boundary line. Even though most of the commercial neural

networks can be retrained to recognize the different kinds of letters on engineering drawings to increase recognition accuracy, it is more important to evaluate whether the selected vendor's recognition engine has a good segmentation algorithm for our application.

Currently, preprocessing and segmentation algorithms encounter difficulty if the drawings and characters are touching, broken, or noisy. The accuracy of the identification recognition results was very high for the engineering drawings complying with standard format and with good quality raster image. The CADA acceptance criteria shall reject those engineering drawings where identification of the title block can not be successfully processed.

4.2.3 Post Recognition Validation

Once a character image is isolated and possible winning target candidates are selected by the recognition process, the final recognition selection can be decided normally by the highest confidence level of each character. The candidate character's confidence level is one of the ordinary output data for most commercially available intelligent character recognition engines. There are other factors that can be used to provide better selection, if the context environment of the character is known and defined. For example, if the character to be recognized is a part of a word, then the final outcome will be validated against words in a dictionary. Characters creating a correctly spelled word will be picked, despite the low confidence level calculated by the recognition engine. The predefined rule may include whether it is a field of alpha or numerical characters, or by the number of characters present in the field, etc. Therefore, post recognition validation can add additional heuristics, and new rules can be defined in advance to influence the final character selection decision.

Postprocessing is very much dependent on a particular form and its application. Once we can successfully correlate a box in the title area to the context environment of the image to be recognized, the accuracy of the resultant recognition can be significantly improved. There is a significant amount of intelligent software which must be implemented in order to do the postprocessing. Due to the current test schedule, only a very limited amount of work was done in the postprocessing area. The efforts in this area are to be enhanced during the integration test phase in order to improve recognition accuracy.

4.3 TEST RESULTS

The identification recognition tests were done on Sun Sparc Workstations and PCs. Two out of the four vendors participated in the test using Sun Sparc workstation, and the other two use PC. The Sun Sparc Workstations are configured with Sun OS Version 4.1.1 and OpenWindows Version 3.0. The PCs are configured with Intel 80386 or 80486 chip and Microsoft Windows Version 3.0.

For each engineering drawing file tested for ID recognition, four fields were to be recognized: drawing number, sheet number, size, and FSCM number. Detailed test results, for each individual engineering drawing by vendor name are included in a tabular form in Appendix C. In Appendix C, the original value and the recognized value for each field of all tested engineering drawings are

both listed in the table for side-by-side comparison. All correctly recognized fields and characters were counted and the percentage of correct recognition ratio were calculated.

The following paragraphs summarize the test results of test Steps 1, 2 and 3 as delineated in Section 2.2.

4.3.1 ID Data Set 1 Used for Tools Selection

The first step to perform the identification recognition test was to select the commercially available tools to perform the identification. The following is the preliminary list of available vendors initially selected as the potential candidates to perform the identification recognition test:

AT&T,
HNC,
Nestor,
OCR systems/Non-Linear Technology (NTI),
VisionShape,
MCC,
Symbus,
CAERE,
Calera,
Datacap,
Ektron,
NYNEX,
OCRON, and
Recognitto.

Some of the above vendors had participated in the preliminary test which was conducted for the previous phase of the CADA technical report (see *Technical Report, Testing Techniques for Data Acceptance Procedures*, 12 July 1991). Each vendor was given the approximately 200 title block images in the ID Data Set 1 which were produced and obtained as described in Section 2.2. The vendors were asked to provide their test results based on the provided ID Data Set 1 Data. ID Data Set 1 were used by vendors for that neural network training as well as for their initial feasibility test.

As the result of the first step, four vendors were selected based on their test performance. The four companies that were selected and joined the follow-on tests were MCC, Nestor, OCR/NTI and VisionShape. The other companies were eliminated due to one or more of the following reasons:

- did not have ICR recognition technology that is necessary to provide required recognition accuracy to satisfy our needs;
- could not have their product ready to meet our test schedule;
- did not have preprocessing capability to utilize their ICR technology;
- would not participate due to lack of short term incentives; or
- needed specialized hardware.

4.3.1.1 Description of Tools Tested

This paragraph describes the tools selected for testing. The four tools selected are:

- NestorReader™ version 1.0 by Nestor. NestorReader accepts binary images in both TIFF and PCX formats, segments and recognizes both constrained and unconstrained touching characters, and does its own image compression and decompression. Nestor added pure text extraction to the front-end of the NestorReader software for the preprocessing step of the CADA tests so that the identified candidate character string image could be recognized by NestorReader. Nestor has specially trained neural networks for different types of characters, such as machine-printed, hand-written, alphabetic, numeric, etc. Character recognition capability was improved by adding additional segmentation algorithms and further neural network training of the hand-printed characters on the engineering drawings.

- ReadRight OCR by OCR Systems/NTI. NTI's product performs reasonably well and at an acceptable speed without additional hardware boards to accelerate the PC. It has the capability of recognizing handwritten characters of alphabetic, numeric, or mixed type. It has the capability of distinguishing mixed alphabetic and numeric characters and has a better recognition accuracy than any other software that was tested. NTI uses line tracing techniques to locate the boxes in the title block area in order to perform the preprocessing function.

- Microelectronics and Computer Technology Corporation(MCC) used a supervised learning algorithm (back propagation), developed in their laboratory environment, to recognize and segment the hand-printed numerical characters with overlapping. They do not, however, have the capability of preprocessing. The front-end text image extraction was performed by Act Laboratory, Altamonte Springs, FL. The Act Laboratory's preprocessing algorithm used corner matching technology.

- VisionShape, Inc., developed AUTOCLASS which performs automatic form processing on an IBM PC or PC compatible machines. AUTOCLASS uses neural network technology to recognize and identify the structure and each field within a form, in contrast to the other companies, which use image technology to locate the fields in a form by lines and boxes. Visionshape's primary business area is in form processing while the other three selected companies are in the area of character recognition. Thus, the product provided by VisionShape exhibits a different approach. Some of the other companies involved in this test have suggested that they will, in the future, experiment with preprocessing similar to Visionshape's approach. The VisionShape experience and results have provided a good lesson on this type of approach for form structure recognition.

4.3.2 ID Data Set 2 Results

The statistics of the test results were calculated by two major indicators: the percentage of correct characters recognized and the percentage of correct fields recognized. There are four fields in an engineering drawing title block to be identified: drawing number, sheet number, size, and FSCM number. Table 4-1 shows the test results for the Data Set 2 test data. There is a total of 73 files of engineering drawings selected in the Data Set 2. It includes 254 fields which consist of 1191 characters, in total, to be identified for this test. Visionshape's software failed to process some of the Data Set 2 files. Those files are excluded from the results statistics.

Table 4-1. ID Data Set 2 Results

	Nestor	NTI	MCC	VisionShape
Total Fields Tested	254	254	254	188
Field Recognized	89	90	62	38
Percentage Correctly Recognized Fields	35%	35%	24%	20%
Total Characters Tested	1191	1191	1191	799
Characters Recognized	638	580	542	344
Percentage Correctly Recognized Characters	54%	49%	46%	43%

4.3.2.1 Overall Recognition Results

The overall recognition test results for the Identification Recognition were in the range of 43% to 54% for correct characters recognized and 20% to 35% for correct fields recognized.

Nestor has the highest rating (54%) of overall character recognition. Both Nester NTI have the highest rating (35%) if counting each field as the basic recognition unit.

The overall recognition percentage was lower than expected. One reason for the low percentage was that the vendors' software did not perform well in the preprocessing stage to capture the right text image that can be recognized.

It is a major challenge to locate the title block within the raster image of an engineering drawing. The data set used in this test does not have good raster image quality (there are broken lines that make the identification of the border of a box difficult). It is believed that with a data set of better raster image quality, the recognition percentage can be improved considerably. ID Data Set 3 was selected with better quality of raster data and the next step (Step 3) of the test procedure was conducted to prove the concept of this idea as described in 4.3.3.

4.3.2.2 Detailed Analysis

Nestor has provided the tool with the most stable software of the four products tested. Its final character recognition capability was specially tailored to recognize numerics and machine-printed

alphabetic for the type of characters used in the engineering drawings. Due to the pure text extraction technique used in the preprocessing, an additional software capability must be added at a later date to automatically correlate the recognized characters with their original fields.

NTI's recognition engine is the fastest of the products tested, and uses the least computer resources. Their neural network and recognition engine training method have some basic differences with others, as NTI claims. NTI uses line tracing techniques to find boxes in the title block area to perform the preprocessing function. This method does not work well for drawings with poor raster line quality. For the drawings with good raster line quality, NTI's product has the highest recognition ratio.

MCC uses ACT laboratory's preprocessing algorithm that uses corner matching technology to find text images in the boxes. The problem with this approach is that it is very sensitive to the other objects around the corners, such as raster image noise and footnotes near the corners, etc. The preprocessing software used for the test is in the development stage, and is not very stable when processing bad quality image data; processing time is also slow.

VisionShape trained its neural network Autoclass to locate the boxes in engineering drawings. Autoclass performs recognition of fields by line location and relative position matching of these intersecting lines. Like the line tracing method, processing and recognition of broken and poor quality lines was a challenge. Visionshape's current software works well only for the engineering drawings with standard format. There software is not stable to process title blocks that may deviate from standard formats.

4.3.3 ID Data Set 3 Results

The statistics of the test results were calculated by two major indicators: the percentage of correct characters recognized and the percentage of correct fields recognized, in a similar fashion to the Data Set 2 test results. Table 4-2 shows the test results for the Data Set 3 test data. There is a total of 88 files of engineering drawings selected in the Data Set 3. It includes 311 fields which consist of 1474 characters in total to be identified. VisionShape's software failed to take some of the Data Set 3 files as input. The Visionshape's statistical results exclude those files.

Table 4-2. ID Data Set 3 Results

	Nestor	NTI	MCC	VisionShape
Total Fields Tested	311	311	311	91
Field Recognized	177	280	192	34
Percentage Correctly Recognized Fields	57%	90%	62%	37%
Total Characters Tested	1474	1474	1474	451
Characters Recognized	990	1405	1229	228
Percentage Correctly Recognized Characters	67%	95%	83%	51%

4.3.3.1 Overall Recognition Results

The overall recognition test results for the Identification Recognition were in the range of 51% to 90% for the percentage of correct character recognized and 57% to 90% for the correct fields recognized. The ID Data Set 3 test results are better than the ID Data Set 2 test results for all the four tools. The same version of software for each vendor was used for both the tests. The only difference between the two tests were the different data sets used; however, this data is more representative of the quality of CALS data expected to be received from contractors. The test results show marginal improvements for Nestor's and Visionshape's software, but they show a two fold increase in the recognition percentage of NTI's and MCC's scftware. The reasons are presented in the Detailed Analysis Section below.

NTI has the highest rating of overall character and field recognition percentages of 95% and 99% respectively. The good recognition percentages were at the level expected due to the better image quality in the ID Data Set 3. The improved image allows better preprocessing to locate the boxes and the text images in the boxes to generate a candidate image to perform character recognition. The improved raster image actually does not change the recognition of the capability as much as the preprocessing capability because there was no change in the nature of the printing style of characters.

4.3.3.2 Detailed Analysis

For Nestor's tool, this test data set, with enhanced quality of lines and boxes, does not help much in increasing Nestor's preprocessing or recognition capability. Because of the fact that Nestor's preprocessing does not locate the lines and boxes to identify the text field images, the enhanced raster image does not improve the Nestor's recognition capability. The better raster quality image will help their preprocessing capability at a later date, to automatically correlate the recognized characters with the original fields.

NTI's recognition percentage had the most improvement in the test results for this set as compared to the ID Data Set 2. With the improved line and box quality, the preprocessing step of NTI's software was able to locate more accurately the text images to be recognized by its recognition engine. The high recognition rate of NTI's results did demonstrate the superior recognition algorithms used in their products. The recognition rate of their recognition engine was claimed by NTI at 95% to 99% level; however, the test results were at a 90% tom95% level for this test case.

MCC's test results show the same improvements as NTI's due to the same reason that MCC's recognition engine was able to locate the target text image more accurately for recognition. The MCC's software is in development and runs very slowly. MCC is investigating incorporating their algorithm into an LSI chip for high performance.

Visionshape's test was mainly for studying the feasibility of performing the preprocessing using neural network technology. Character recognition was not one of Visionshape's strong points. Due to the unstable condition of Visionshape's software, the test is not conclusive. For the whole test suite, less than 40% of data files were able to be processed.

4.4 SUMMARY OF TEST RESULTS

The following paragraphs summarize the results of the identification recognition testing.

1. With the current pre-processing and recognition technology, the achieved percentage of successful recognition rate on good data is above 90%. Among the four tools tested, NTI has the best test results followed by MCC's test result as a close second.

2. In addition to the recognition rate, some other factors were considered and a comparison was made for the four tools tested. Table 4-3 shows the results of overall comparison by the factors considered. The indicators used in the Table are L : Low, M : Medium, and H : High. As indicated in the table, both NTI and MCC have the most of the High marks.

Table 4-3. Test Summary

	Nestor	NTI	MCC	VisionShape
General				
1) flexibility to for integration into CADA system;	M	M	M	M
2) speed;	M	H	L	H
3) software quality and stability	H	M	M	L
4) Application Program Interface (API)	M	L	L	L
Preprocessing Test				
1) box finding capability;	L	H	H	M
2) text finding capability;	H	H	H	M
3) key field correlation	L	H	H	M
4) line and box removal;	H	H	H	H
Character Recognition Test				
1) character segmentation accuracy;	M	H	M	L
2) character recognition accuracy;	M	H	H	L
3) neural network trainability for new character styles	not tested	not tested	not tested	not tested
Postprocessing Test Criteria				
1) heuristic capability	not tested	not tested	not tested	not tested
2) validation capability	not tested	not tested	not tested	not tested

Key: H : High M : Medium L : Low

SECTION 5

CONCLUSIONS

5.1 IMAGE TESTING

Several important conclusions can be made from the image testing conducted in this phase of the project. The following paragraphs describe those conclusions.

1. The CADA tools for field testing should allow the operators to configure the techniques and parameters, due to differences in data characteristics and quality assurance standards across various organizations.

2. A combination of five techniques was identified for a high level of quality control standards that should be applicable to new data received from the contractors. Using this combination on the limited suite of test data, a false accept (FA) rate of less than 1 % and a false reject rate of 22% was obtained.

3. Objective criteria must be used in the QA process for CALS data. The automated quality analysis techniques can be most effectively used if the quality control is based on objective criteria like conformance to ANSI standards for line widths, absence of noise, lack of fading, etc., rather than on subjective judgement and interpretation of the contents of data.

5.2 IDENTIFICATION TESTING

The following conclusions can be made for the identification recognition testing.

1. The application of the neural network techniques do hold promise for automated ID recognition, and three vendors' software have been identified that give good results recognizing hand printed and machine printed information.

2. The technology is mature enough to automate the identification recognition processing for the drawings that meet the ANSI standards.

3. The type of characters trained by each individual neural network affects the recognition results. Different types of characters include machine printed, constrained hand-printed and unconstrained hand-scripted. Neural networks perform well if the target characters can be classified as one of these types.

4. The neural network provided by NTI is much less sensitive about the type of characters to be recognized, and the recognition accuracy of the NTI engine is better than those of other companies.

SECTION 6

RECOMMENDATIONS

6.1 IMAGE TESTING

1. It is recommended that all new data prepared by government contractors should be required to adhere to the government recommended ANSI Y14.2M standard. This standard defines the line conventions and lettering requirements for engineering drawings. If all contractors are required to adhere to this standard by contract, the use of image quality techniques will produce the best results.

2. It is recommended that the quality requirements of new data procured by the government contractors be clearly specified in the contract in objective terms. Currently, the quality assurance is based on subjective criteria like "legibility and reproducibility," which are not well suited for automated quality assurance procedures. These procedures would be most effective if the contract specifies objective criteria like acceptable limits of some of the noise parameters used in this test.

6.2 IDENTIFICATION TESTING

The following recommendations are made for the future improvements on the identification recognition.

1. It is recommended that more effort be devoted to the pre-processing area. There are no readily available COTS software packages that can be directly used. The CADA task should develop the needed pre-processing capability. Locating the revision number in an engineering drawing is by far the most difficult task of all. Since the revision number column holds all revision history, it is dynamically expanded each time the revision is made to the drawing. The method to locate the revision number correctly has yet to be defined.

2. It is recommended that additional Postprocessing of the data be performed during the integration phase of the CADA task.

3. It is recommended that contracts for procurement of new engineering drawing data specify that ANSI standards Y 14.1 and Y 14.2 be met. This especially applies to the format, letter, and line requirements of the ANSI standards.

SECTION 7

ACRONYMS AND GLOSSARY

ANSI	American National Standards Institute
API	Application Program Interface
CAD	Computer-Aided Design
CADA	Computer-Assisted Data Acceptance
CALS	Computer-aided Acquisition and Logistic Support
CCITT	Consultative Committee for International Telephony and Telegraphy
CDRL	Contract Data Requirements List
CIT	Consumable Item Transfer
CR	Compression Ratio
CTC	CALS Technology Center
CTN	CALS Test Network
CTNO	CALS Test Network Office
DID	Data Item Description
DoD	Department Of Defense
DSREDS	Digital Storage and Retrieval Engineering Data System
EDCARS	Engineering Data Computer Assisted Retrieval System
EDMICS	Engineering Data Management Information Control System
EDP	Engineering Drawing Package
FA	False Accept
FA	False Reject
FF	File Format
GB	Gigabyte
ICR	Intelligent Character Recognition
ID	Identification Data
ICR	Intelligent Character Recognition
LAN	Local Area Network
OCR	Optical Character Recognition
PM	Program Management/Project Manager
ppm	parts per million
QA	Quality Assurance
QC	Quality Control
SOW	Statement of Work
TIFF	Tagged Image File Format

SECTION 8

REFERENCE DOCUMENTS

Technical Report - Testing Techniques for Data Acceptance Procedures. July 12, 1991.

CCITT Blue Book, Vol VII - Fascicle VII.3, T*erminal Equipment and Protocols for Telematic Services,* Recomm. T.0-T.63.

ANSI Y14.1-1975, *American National Standard for Engineering Drawings and Related Documentation Practices*; American Society of Mechanical Engineering

ANSI Y14.2M-1979, *American National Standard for Engineering Drawings and Related Documentation Practices*; American Society of Mechanical Engineering

MIL-M-9689D Military Specification *Microfilming of Engineering Documents, 35MM, Requirements for*

MIL-STD-1840A, *Military Standard, Automated Interchange of Technical Information,* 20, December 1988

MIL-R-28002A *Raster Graphics Representation in Binary Format, Requirement for,* 30, November 1990

APPENDIX A
TEST PLAN

1. Introduction and Background

Computer-assisted Data Acceptance (CADA) procedures for Government acceptance of CALS Raster, Type I data have been prepared. Implementation of these procedures, in the acceptance of CALS data, requires that image and identification recognition techniques be thoroughly analyzed, tested and integrated prior to conducting field operational testing at the Services repositories.

2. Objective

This plan defines the procedures required to conduct testing of image quality algorithms and candidate vendor Intelligent Character Recognition (ICR) techniques and engines. A report will be prepared which shows the results of testing both existing DSREDS and EDCARS data and CALS-equivalent quality data.

3. Standards and Specifications

3.1 MIL-STD-1840A, *Military Standard, Automated Interchange of Technical Information,* 20, December 1988

3.2 MIL-R-28002A *Raster Graphics Representation in Binary Format, Requirement for,* 30, November 1990

4. Procedures

The scope of the testing effort requires that input data for image analysis and identification recognition tests be prepared or obtained and used as the basis for evaluating image quality algorithms and candidate vendors' ICR techniques and products. The procedures include image quality and identification recognition testing.

4.1 Image Quality Algorithms Test Procedures

a. Obtain representative test data from DSREDS and EDCARS.

b. Create or obtain CALS equivalent quality test data.

c. Classify the test data prior to testing.

d. Select image algorithms for evaluation and testing.

e. Conduct individual and integrated testing of the algorithms on DSREDS/EDCARS data and on high quality CALS-compliant data.

f. Document and analyze the test results.

g. Prepare results and analysis for delivery in a test report.

4.2 Identification Recognition Test Procedures

a. Prepare a suite of test data from the representative DSREDS and EDCARS samples.

b. Prepare a suite of test data to represent CALS-compliant data.

c. Identify ICR vendors for product evaluation.

d. Prepare specification for identification recognition evaluation testing.

e. Conduct testing of identified vendor products at the Army CTN Test Bed on both existing DSREDS / EDCARS data and CALS equivalent quality.

f. Document and analyze the test results.

g. Prepare results and analysis for delivery in a test report.

5. Facilities and Equipment

The following facilities and equipment will be used when this test plan is executed:

5.1 Facilities

The Army CTN Test Bed located at the PM JCALS CALS Technology Center (CTC), Ft. Monmouth, NJ.

5.2 Hardware:

a. Sun Sparc workstation 370 computer system with 9-track tape drive;

b. ComputerVision CDS 3000 with 9-track tape drive;

c. Apple Macintosh IIcx computer system;

d. Gateway PC 486 computer system;

e. Intergraph InterPro 2000 computer system; and

f. Ethernet local area network.

5.3 Software:

a. Application Software routines in "C" to develop and integrate image analysis routines with;

b. User interface routines;

c. CCITT Decompression routines;

d. CTN Tape tool routines;

e. Intergraph conversion routines; and

f. Candidate vendor identification recognition routines.

6. Deliverables

A Techniques Test Report entitled *Phase III: Computer-Assisted Data Acceptance* will be delivered on 26 May 1992..

7. Schedule

See Figure A-1.

SCHEDULE - PHASE III TECHNIQUES TESTING									
Fiscal Yeal -->	FY91->	<-- FY92 ----------------							
Calendar Year -->	<-------------- 1991 ---------------->				<-- 1992 ---				
Month -->	**SEPT**	**OCT.**	**NOV.**	**DEC.**	**JAN.**	**FEB.**	**MAR.**	**APRIL**	**MAY**
TASK DESCRIPTIONS		**|<- TECHNIQUES TESTS --**				------|<-- Task Stop-->|			o----->|
						|<-- Task Stop-->|			
Prepare Test Data - Image	o- - - - - --------->					|<-- Task Stop-->|			
Prepare Test Data - ID		o - - - - - --------------->				|<-- Task Stop-->|			
Analyze Existing Image Techns	o - ----------->					|<-- Task Stop-->|			
Obtain Services Test Data		o - - - - - - --------->				|<-- Task Stop-->|			
Classify Test Data - Image / ID				o - - --------->		|<-- Task Stop-->|			
Develop New Image Techns.			o ------------>			|<-- Task Stop-->|			
Neural Net Vendor Evaluation		o- - --------------->				|<-- Task Stop-->|			
Vendor ID Tests - External				o - - ------>		|<-- Task Stop-->|			
CTC Tests - Neural Net Techn.					o------>	|<-- Task Stop-->|			
Test DSREDS / EDCARS Data.				o - -------------->		|<-- Task Stop-->|			
Analyze DSREDS /EDCARS					o-	------|<-- Task Stop-->|			o->
Test CALS Type Img. Data					o------	------|<-- Task Stop-->|			o-->
Test CALS Type ID Data					o---	------|<-- Task Stop-->|			o-->
Analyze Image Test Results						|<-- Task Stop-->|			o-->
Analyze ID Test Results						|<-- Task Stop-->|			o-->
Prepare Test Report						|<-- Task Stop-->|			o---->
Deliver Test Report						|<-- Task Stop-->|			**X**

Figure A-1. Test Plan Schedule

APPENDIX B
IMAGE ANALYSIS RESULTS

This appendix gives detailed results for the following two cases of image quality testing:

1. Image Data Set 1 using "High Quality" criteria.

2. Image Date Set 2 using "Low Quality" criteria.

File,Drawing No.,Size,Fill Factor,Run Length Rat.,App. Blk. Orph. Rat., Tile Noise,App. Wht. Orph. Rat.,Vis. A/R,Auto A/R
DWG001,584R0G2,A,2.809517,6.855692,0.003398,16,0.160455,A,A
DWG002,DLSC-B-448720,B,5.831428,100,0.320065,1464,6.914885,R,R
DWG003,DLSC-B-506260,B,5.329199,100,0.325877,1314,7.34985,R,R
DWG004,584R0G2,A,2.411362,5.382675,0.002435,21,0.191598,A,A
DWG005,584R0G2,A,0.289246,88.0662,0.014642,172,2.884264,R,R
DWG006,584R0G2,A,40.954376,100,2.349324,3084,5.652566,R,R
DWG007,584R0G2,A,2.377147,35.193291,0.016361,73,0.551971,R,R
DWG008,SM-A-497381,A,12.572836,59.454041,0.074617,276,0.638098,R,R
DWG009,SM-A-497381,A,12.561038,34.721786,0.044173,149,0.436122,R,R
DWG010,SM-A-497381,A,10.182355,100,0.260408,532,1.640154,R,R
DWG011,SM-A-497381,A,23.261328,100,2.160809,3997,9.973362,R,R
DWG012,SM-A-497381,A,10.768659,97.90786,0.084181,423,0.89347,R,R
DWG013,SM-A-497381,A,8.54867,100,0.266504,900,1.976282,R,R
DWG014,SM-A-497381,A,8.463961,3.095277,0.009163,21,0.129437,A,A
DWG015,DLSM-A-496855,A,11.860601,7.784946,0.022914,47,0.287589,A,R
DWG016,DLSM-A-496855,A,11.917838,8.514351,0.024488,51,0.296176,A,R
DWG017,DLSM-A-496855,A,11.876759,35.838482,0.10899,264,0.758005,R,R
DWG018,1071010,B,1.691709,31.814846,0.035406,357,1.088189,R,R
DWG019,1071010,B,2.294757,38.693218,0.016837,259,0.365701,R,R
DWG020,1071010,B,0.970695,72.488342,0.013774,80,0.867274,R,R
DWG021,1071010,B,6.269595,3.305285,0.006139,35,0.181656,A,A
DWG022,206803-00,B,9.294185,4.986814,0.009678,72,0.147478,A,A
DWG023,206803-00,B,6.70487,13.016374,0.024215,318,0.543362,R,R
DWG024,3100109-007,B,0.227715,100,0.015006,226,1.7432,R,R
DWG025,3100109-007,B,1.172554,60.550663,0.038899,257,1.176925,R,R
DWG026,3100109-007,B,6.410872,23.967255,0.040877,264,0.566825,R,R
DWG027,3100109-007,B,9.973505,1.854949,0.005563,19,0.074393,A,A
DWG028,3100109-007,B,8.775868,6.083761,0.011463,82,0.188974,A,A
DWG029,3100109-007,B,0.038536,81.25,0.002052,67,0.864155,R,R
DWG030,3100109-007,B,0.011203,100,0.002545,69,7.134364,R,R
DWG031,3100109-007,B,8.920103,4.637137,0.00996,67,0.128127,A,A
DWG032,SM-B-358615,B,12.377357,7.896937,0.026604,220,0.32652,R,R

DWG033,SM-B-3586151,B,16.462383,100,0.849022,3574,2.70499,R,R			
DWG034,SM-B-3586152,B,34.056572,100,1.614886,3273,3.902382,R,R			
DWG035,SM-B-386026,B,7.966486,12.755826,0.020118,610,0.396616,R,R			
DWG036,SM-B-386026,B,8.326034,6.684573,0.011363,241,0.298535,R,R			
DWG037,SM-B-386026,B,8.990263,8.24788,0.01629,202,0.254253,A,R			
DWG038,SM-B-387525,B,21.092724,100,0.513241,1245,2.137959,R,R			
DWG039,SM-B-387525,B,7.688885,13.461376,0.023593,645,0.408856,R,R			
DWG040,SM-B-387525,B,8.127984,7.168445,0.013426,317,0.351042,R,R			
DWG041,SM-B-387525,B,9.162457,9.786272,0.021278,161,0.290327,A,R			
DWG042,SM-B-389801,B,23.302656,100,1.307699,2682,3.742532,R,R			
DWG043,SM-B-389801,B,10.723332,5.651083,0.013906,52,0.175647,A,A			
DWG044,SM-B-389801,B,8.794344,3.885219,0.010107,102,0.187668,A,A			
DWG045,SM-B-389809,B,8.043518,10.835187,0.015471,198,0.3226,R,R			
DWG046,SM-B-389809,B,8.340406,6.13417,0.009257,67,0.258892,R,R			
DWG047,SM-B-389809,B,8.969815,5.299145,0.010682,89,0.166325,A,A			
DWG048,SM-B-389853,B,12.129236,100,0.382195,1158,1.722775,R,R			
DWG049,SM-B-389853,B,5.741875,9.464958,0.010995,79,0.31365,A,R			
DWG050,SM-B-389853,B,6.008219,6.670488,0.008036,57,0.279571,R,R			
DWG051,SM-B-389853,B,6.3472,5.24377,0.006329,47,0.199372,R,A			
DWG052,SM-B-389853,B,6.569933,5.444013,0.007685,120,0.169905,A,A			
DWG053,SM-B-389899,B,11.125933,100,0.333905,985,1.35517,R,R			
DWG054,SM-B-389899,B,5.382473,9.100015,0.010967,139,0.367013,R,R			
DWG055,SM-B-389899,B,5.992674,3.580742,0.005781,27,0.20472,A,A			
DWG056,SM-B-389899,B,6.22248,5.486606,0.00865,97,0.178321,A,A			
DWG057,SM-B-389917,B,10.03763,100,0.287059,874,1.515238,R,R			
DWG058,SM-B-389917,B,5.380461,3.42545,0.004618,56,0.195582,A,A			
DWG059,SM-B-389917,B,4.904558,7.649549,0.010113,88,0.361222,R,R			
DWG060,SM-B-389917,B,5.551617,6.6949,0.007672,85,0.182354,A,A			
DWG061,SM-B-389926,B,6.678895,3.73072,0.005924,84,0.209215,A,A			
DWG062,SM-B-389926,B,11.419477,100,0.172889,519,1.032565,R,R			
DWG063,SM-B-389926,B,6.124441,7.458336,0.010401,89,0.347127,R,R			
DWG064,SM-B-389926,B,6.908674,5.613681,0.008485,150,0.273982,A,R			
DWG065,SM-B-448830,B,7.958467,5.445806,0.00974,60,0.240686,A,A			

DWG066,SM-B-448830,B,7.448476,10.514156,0.016537,169,0.30724,R,R			
DWG067,SM-B-448830,B,9.060288,10.111938,0.015717,151,0.235675,A,A			
DWG068,SM-B-503001,B,12.556386,10.512236,0.026689,182,0.340536,A,R			
DWG070,SM-B-5030011,B,16.770714,100,0.567845,1360,2.110307,R,R			
DWG071,SM-B-5030012,B,25.357244,100,1.091659,2592,2.791735,R,R			
DWG072,SM-B-5030012,B,29.151508,100,1.216924,2641,2.760066,R,R			
DWG073,DLSC-B-448720,B,11.536355,100,0.439117,1565,1.909008,R,R			
DWG074,DLSC-B-448720,B,5.965118,6.533021,0.00831,30,0.176444,A,A			
DWG075,DLSC-B-448720,B,5.935589,9.737638,0.011472,51,0.230608,A,A			
DWG076,DLSC-B-506260,B,12.406576,100,0.489191,1278,1.999404,R,R			
DWG077,DLSC-B-506260,B,5.11176,19.817305,0.015798,77,0.518389,R,R			
DWG078,DLSC-B-506260,B,6.23404,11.061265,0.01046,24,0.192921,A,A			
DWG079,SMSM-B-389801,B,4.994747,3.374367,0.003659,55,0.166208,A,A			
DWG080,SMSM-B-389801,B,6.27102,9.380496,0.012805,81,0.359405,R,R			
DWG081,SMSM-B-389801,B,6.52447,5.632007,0.007766,38,0.292157,R,R			
DWG082,SMSM-B-389801,B,13.323436,100,0.399878,1073,1.56516,R,R			
DWG083,SMSM-B-389801,B,7.096494,3.503854,0.006008,39,0.148475,A,A			
DWG084,1062001,C,5.967994,3.030972,0.005133,87,0.171787,A,A			
DWG085,1062001,C,3.287464,29.575987,0.037412,240,0.911973,R,R			
DWG086,1062001,C,6.91399,1.91378,0.003716,20,0.106813,A,A			
DWG087,SC-C-609601,C,18.666719,100,0.614981,2693,3.173502,R,R			
DWG088,SC-C-609601,C,5.184449,7.521323,0.00731,66,0.222358,A,A			
DWG089,SC-C-609601,C,5.559968,9.738937,0.011315,196,0.234189,A,R			
DWG090,SM-C-339945,C,9.787708,5.74567,0.018195,354,0.227163,R,R			
DWG091,SM-C-339945,C,1.79917,70.315186,0.086353,585,1.140762,R,R			
DWG092,SM-C-339945,C,12.392894,2.777383,0.013714,71,0.142053,A,A			
DWG093,SM-C-3399451,C,0.479864,100,0.107576,713,5.873647,R,R			
DWG094,SM-C-511175,C,5.595013,5.474004,0.00769,104,0.240009,A,A			
DWG095,SM-C-511175,C,12.184527,100,0.349375,2122,1.663727,R,R			
DWG096,SM-C-511175,C,6.150535,3.747149,0.006313,62,0.13194,A,A			
DWG097,SM-C-545372,C,16.30188,100,0.388632,1423,2.027327,R,R			
DWG098,SM-C-545372,C,6.39764,9.753986,0.011265,163,0.202573,A,R			
DWG099,SM-C-5453721,C,11.358869,100,0.859232,3175,4.719515,R,R			

DWG100,SM-C-545374,C,14.774542,100,0.227258,800,1.39446,R,R				
DWG101,SM-C-545374,C,5.001513,14.605015,0.020601,379,0.41733,R,R				
DWG102,SM-C-545374,C,7.58017,4.658692,0.00999,89,0.178976,A,A				
DWG103,SM-C-563457,C,16.694668,100,0.515964,2292,2.925601,R,R				
DWG104,SM-C-563457,C,3.986433,14.128376,0.012267,127,0.280934,R,R				
DWG105,SM-C-563457,C,5.736045,5.126194,0.008358,46,0.179537,A,A				
DWG106,SM-C-604977,C,6.282519,3.203275,0.00708,39,0.198881,A,A				
DWG107,SM-C-604977,C,6.867668,2.934647,0.008021,40,0.164604,A,A				
DWG108,SM-C-6049771,C,0.447516,100,0.087222,607,5.272516,R,R				
DWG109,SM-C-621535,C,12.662518,100,0.551311,2037,3.078712,R,R				
DWG110,SM-C-621535,C,2.977865,11.105309,0.009225,121,0.321978,R,R				
DWG111,SM-C-621535,C,4.374191,7.376729,0.007799,138,0.18086,A,A				
DWG112,SM-C-6215351,C,0.792653,97.331955,0.069469,507,2.77681,R,R				
DWG113,SM-C-621569,C,15.404882,100,0.562622,2496,2.32915,R,R				
DWG114,SM-C-621569,C,4.698864,11.532469,0.015443,162,0.329168,R,R				
DWG115,SM-C-621569,C,6.993003,3.421934,0.007177,51,0.149711,A,A				
DWG116,SM-C-6215691,C,0.618739,100,0.106165,546,4.041961,R,R				
DWG117,SM-C-652013,C,7.950133,9.814128,0.019925,171,0.31226,R,R				
DWG118,SM-C-652013,C,18.624329,100,0.182143,570,0.940012,R,R				
DWG119,SM-C-652013,C,10.437164,3.123859,0.010661,47,0.133891,A,A				
DWG120,SM-C-652386,C,8.112302,4.404169,0.011787,66,0.277564,A,R				
DWG121,SM-C-652386,C,7.242365,7.725066,0.017589,138,0.307182,R,R				
DWG122,SM-C-652386,C,9.36532,2.561127,0.007517,64,0.132853,A,A				
DWG123,SM-C-652391,C,5.490366,9.854523,0.010145,107,0.261832,R,R				
DWG124,SM-C-652391,C,0.491155,100,0.04517,522,3.53743,R,R				
DWG125,SM-C-652391,C,6.892138,4.605438,0.006159,44,0.113449,A,A				
DWG126,SM-C-652482,C,18.052288,100,0.252285,978,1.231174,R,R				
DWG127,SM-C-652482,C,7.674762,8.124197,0.017038,176,0.27608,R,R				
DWG128,SM-C-652482,C,9.756602,3.136784,0.009189,87,0.138849,A,A				
DWG129,SM-C-662882,C,22.236454,100,0.414333,1013,1.613343,R,R				
DWG130,SM-C-662882,C,8.047677,7.913286,0.016885,126,0.271867,R,R				
DWG131,SM-C-662882,C,10.08019,3.124644,0.010173,29,0.127868,A,A				
DWG132,1041001,D,3.143519,7.24763,0.005426,178,0.194711,R,R				

DWG133,1041001,D,0.889303,36.869896,0.013104,142,0.839553,R,R				
DWG134,1041001,D,3.682458,5.517732,0.004477,78,0.16929,A,A				
DWG135,1041001,D,2.587469,12.410538,0.006998,108,0.32536,R,R				
DWG136,1041001,D,4.58656,3.87102,0.004279,28,0.136137,A,A				
DWG137,1041001,D,1.057192,46.078171,0.018737,194,0.91444,R,R				
DWG138,1041001,D,3.171216,8.637308,0.006834,130,0.283321,R,R				
DWG139,1041001,D,1.714268,27.382683,0.008921,142,0.474383,R,R				
DWG140,1041001,D,3.90634,20.959597,0.01616,91,0.531787,R,R				
DWG141,1041001,D,10.495641,100,0.273389,1782,1.834715,R,R				
DWG142,1041001,D,4.604327,4.632778,0.004933,48,0.145954,A,A				
DWG143,SC-D-279935,D,5.321065,24.242794,0.024934,292,0.368119,R,R				
DWG144,SC-D-279935,D,6.927982,16.522509,0.022066,173,0.369931,R,R				
DWG145,SC-D-279935,D,9.519301,8.49183,0.01311,149,0.186809,A,A				
DWG146,SC-D-2799353,D,5.557148,18.012007,0.018353,154,0.209798,R,R				
DWG147,SC-D-279939,D,4.115149,19.864794,0.015247,141,0.301765,R,R				
DWG148,SC-D-279939,D,13.771839,100,0.170983,1177,1.137076,R,R				
DWG149,SC-D-279939,D,7.42309,6.479169,0.008766,112,0.203404,A,A				
DWG150,SM-D-421722,D,15.660985,100,0.527411,2219,1.876135,R,R				
DWG151,SM-D-421722,D,4.942995,9.920106,0.012636,176,0.228657,R,R				
DWG152,SM-D-421722,D,7.625639,4.266125,0.008385,108,0.139002,A,A				
DWG153,SM-D-422468,D,11.480089,100,0.136576,759,1.052466,R,R				
DWG154,SM-D-422468,D,4.316223,10.797068,0.01238,162,0.28655,R,R				
DWG155,SM-D-422468,D,5.17681,6.368719,0.009637,109,0.229201,R,A				
DWG156,SM-D-422468,D,6.443335,3.819462,0.006952,59,0.135669,A,A				
DWG157,SM-D-425566,D,7.273201,12.29385,0.020848,301,0.25645,R,R				
DWG158,SM-D-425566,D,10.728165,2.273025,0.008233,60,0.137946,A,A				
DWG159,SM-D-425598,D,16.77096,100,0.297263,2038,1.699702,R,R				
DWG160,SM-D-425598,D,10.273447,10.140833,0.018861,374,0.268169,R,R				
DWG161,SM-D-425598,D,6.396856,7.361639,0.012093,279,0.237493,R,R				
DWG162,SM-D-425598,D,5.167027,12.791552,0.014861,271,0.234275,R,R				
DWG163,SM-D-425598,D,8.275002,3.581243,0.008397,181,0.169062,A,R				
DWG164,SM-D-447165,D,14.243663,100,0.223229,1361,1.135673,R,R				
DWG165,SM-D-447165,D,5.095262,14.137618,0.016755,206,0.331036,R,R				

DWG166,SM-D-447165,D,8.12181,4.700671,0.008615,79,0.15462,A,A				
DWG167,SM-D-447166,D,8.440431,100,0.237137,1677,1.341219,R,R				
DWG168,SM-D-447166,D,2.38901,19.668459,0.011173,236,0.358103,R,R				
DWG169,SM-D-447166,D,4.683144,4.495444,0.004664,117,0.153951,A,A				
DWG170,SM-D-447167,D,2.840979,19.125774,0.01117,192,0.349778,R,R				
DWG171,SM-D-447167,D,5.216472,3.478153,0.004033,45,0.139679,A,A				
DWG172,SM-D-447316,D,1.606321,20.871862,0.007263,164,0.378142,R,R				
DWG173,SM-D-447316,D,5.773335,100,0.08675,657,1.108924,R,R				
DWG174,SM-D-447316,D,3.104706,7.108417,0.003928,71,0.173012,A,A				
DWG175,SM-D-4473162,D,7.983043,100,0.396427,2848,3.40992,R,R				
DWG176,SM-D-498259,D,6.655884,100,0.1,774,1.121239,R,R				
DWG177,SM-D-498259,D,1.790844,17.338531,0.008664,114,0.399986,R,R				
DWG178,SM-D-498259,D,2.442582,14.676544,0.009804,263,0.414327,R,R				
DWG179,SM-D-498259,D,3.67713,6.629365,0.005832,55,0.200236,A,A				
DWG180,SM-D-498259,D,13.839008,100,0.340118,1868,1.438462,R,R				
DWG181,SM-D-498259,D,4.785506,17.823973,0.016075,145,0.345991,R,R				
DWG182,SM-D-498259,D,7.656127,5.217644,0.007407,72,0.139536,A,A				
DWG183,1035A2302,E,5.367894,9.19103,0.013458,187,0.234133,R,R				
DWG184,1035A2302,E,1.802455,30.021414,0.02707,209,0.598949,R,R				
DWG185,1035A2302,E,3.446237,11.583179,0.016365,158,0.370034,R,R				
DWG186,57045,E,3.000689,50.878082,0.040033,2325,0.787546,R,R				
DWG187,57045,E,0.321477,74.995178,0.00655,622,2.111307,R,R				
DWG188,57045,E,0.067582,100,0.001894,484,3.113072,R,R				
DWG189,74J658000,E,4.998204,9.876514,0.010888,114,0.232784,A,A				
DWG190,74SB202102,E,1.510767,14.399122,0.008776,169,0.458801,R,R				
DWG191,74SB202102,E,0.271319,48.657257,0.006702,190,0.588362,R,R				
DWG192,74SB202102,E,0.162079,50.162422,0.00506,284,0.500207,R,R				
DWG193,SC-E-107667,E,3.428825,37.860931,0.030053,298,0.638501,R,R				
DWG194,SC-E-107667,E,5.002566,19.747437,0.024033,173,0.473599,R,R				
DWG195,SC-E-107667,E,7.630359,13.721996,0.02041,171,0.372887,A,R				
DWG196,SC-E-352151,E,4.578639,18.455166,0.026709,190,0.412379,R,R				
DWG197,SC-E-352151,E,6.100204,10.313733,0.021483,141,0.319679,R,R				
DWG198,SC-E-352151,E,8.53581,6.004694,0.015591,62,0.17067,A,A				

DWG199,SC-E-64667,E,0.150216,65.421997,0.003243,152,0.989094,R,R			
DWG200,SC-E-64667,E,0.772583,39.201946,0.007956,116,0.622905,R,R			
DWG201,SC-E-64667,E,6.323721,26.233818,0.015981,95,0.250556,R,R			
DWG202,SC-E-64667,E,2.026374,42.10128,0.016555,301,0.598481,R,R			
DWG203,SC-E-64667,E,5.032355,13.65811,0.01029,114,0.218788,R,A			
DWG204,SC-E-660257,E,6.080462,17.529331,0.016583,174,0.285153,A,R			
DWG205,SC-E-660257,E,4.786671,9.761998,0.010162,108,0.260848,A,R			
DWG206,SC-E-726621,E,10.307312,16.837086,0.030417,250,0.296585,R,R			
DWG207,SC-E-726621,E,4.092155,29.141375,0.022254,253,0.379249,R,R			
DWG208,SC-E-726621,E,5.618905,17.987879,0.019638,219,0.283624,R,R			
DWG209,SC-E-726621,E,8.220376,7.473114,0.016804,98,0.235069,A,A			
DWG210,SC-E-73118,E,0.041751,100,0.002378,173,2.503511,R,R			
DWG211,SC-E-73118,E,1.619394,39.650253,0.016163,246,0.718272,R,R			
DWG212,SC-E-73118,E,6.334174,19.532787,0.0206,307,0.372291,R,R			
DWG213,SC-E-73118,E,0.539357,35.544041,0.006949,329,0.773311,R,R			
DWG214,SC-E-73118,E,5.034195,9.500946,0.011564,133,0.291944,A,R			
DWG215,SC-E-73118,E,3.896215,7.243247,0.008579,93,0.244625,A,A			
DWG216,SC-E-749961,E,4.299547,24.127676,0.014057,130,0.305556,R,R			
DWG217,SC-E-749961,E,5.126072,14.841112,0.01086,134,0.255831,R,R			
DWG218,SC-E-749961,E,6.615172,12.57001,0.011178,104,0.224805,A,A			
DWG219,SM-E-106987,E,0.485022,55.644756,0.010779,283,0.992561,R,R			
DWG220,SM-E-106987,E,1.894277,36.52034,0.019727,351,0.568944,R,R			
DWG221,SM-E-106987,E,7.061821,11.12683,0.016149,105,0.252784,A,A			
DWG222,SM-E-115852,E,0.003055,100,0.000347,65,2.412281,R,R			
DWG223,SM-E-115852,E,0.271319,27.12413,0.004184,118,0.453774,R,R			
DWG224,SM-E-115852,E,0.979702,36.581718,0.011706,162,0.740159,R,R			
DWG225,SM-E-115852,E,8.106534,100,0.279843,1917,1.926776,R,R			
DWG226,SM-E-115852,E,3.467572,14.179472,0.01047,105,0.273657,A,R			
DWG227,SM-E-115921,E,15.736182,100,0.210574,1320,1.021015,R,R			
DWG228,SM-E-115921,E,6.01762,18.165298,0.02417,255,0.382689,R,R			
DWG229,SM-E-115921,E,9.356751,5.875846,0.016137,116,0.175871,A,A			
DWG230,SM-E-115986,E,3.730887,27.066988,0.017014,157,0.418442,R,R			
DWG231,SM-E-115986,E,10.703081,100,0.178523,1163,1.173992,R,R			

DWG232,SM-E-115986,E,5.937855,10.475031,0.012389,76,0.185283,A,A				
DWG233,A02R2701,E,7.905501,100,0.069551,588,0.646549,R,R				
DWG234,A02R2701,E,2.350524,39.503399,0.020528,191,0.474828,R,R				
DWG235,A02R2701,E,0.00003,66.666664,0.000003,2,5.263158,R,R				
DWG236,A02R2701,E,2.439619,80.718063,0.029705,201,0.844254,R,R				
DWG237,A02R2701,E,0.15921,100,0.003746,131,1.599209,R,R				
DWG238,A02R2701,E,1.673739,76.597771,0.020504,166,0.74539,R,R				
DWG239,1035A2302,E,2.365581,100,0.101325,1625,5.518424,R,R				
DWG240,1035A2302,E,2.820085,100,0.156822,2659,8.193848,R,R				
DWG241,A02R2701,E,2.740186,100,0.162204,2888,9.903544,R,R				
DWG242,SC-E-107667,E,3.407424,100,0.174047,2507,8.404364,R,R				
DWG243,SC-E-352151,E,4.501436,100,0.301372,2956,11.040289,R,R				
DWG244,SC-E-64667,E,2.036965,100,0.107137,1534,8.232378,R,R				
DWG245,SC-E-660257,E,2.070127,100,0.097914,1608,6.913466,R,R				
DWG246,SC-E-726621,E,4.243059,100,0.192749,2977,7.233272,R,R				
DWG247,SC-E-73118,E,2.691316,100,0.131038,3405,8.639293,R,R				
DWG248,SC-E-749961,E,3.315081,100,0.163033,5144,8.134347,R,R				
DWG249,SM-E-106987,E,2.883084,100,0.115687,1795,6.038016,R,R				
DWG250,SM-E-1158522,E,0.997781,100,0.068463,1136,8.903465,R,R				
DWG251,SM-E-115986,E,3.244248,100,0.244415,2695,14.180164,R,R				
DWG252,A02R2701,E,2.585799,100,0.169805,3005,10.617276,R,R				
DWG253,1071010,E,3.860869,7.998992,0.006619,158,0.177404,R,R				
DWG254,1071010,E,4.967723,21.943203,0.014143,219,0.285734,R,R				
DWG255,1071010,E,1.643985,36.6838,0.018643,260,0.599829,R,R				
DWG256,1071010,E,6.12207,27.266125,0.015834,218,0.260067,A,R				
DWG257,1071010,E,2.589581,28.332907,0.012818,174,0.429766,R,R				
DWG258,1071010,E,3.482749,14.715653,0.009563,113,0.308488,R,R				
DWG259,74J658000,E,0.001627,100,0.000224,43,3.937008,R,R				
DWG260,A02R2701,E,6.359003,100,0.071172,902,1.119255,R,R				
DWG262,A02R2701,E,3.408538,21.245949,0.011962,291,0.353978,R,R				
DWG263,A02R2701,E,7.66464,42.852379,0.032135,246,0.414579,A,R				
DWG264,A02R2701,E,0.163669,84.366234,0.005527,196,1.844252,R,R				
DWG265,A02R2701,E,2.241626,40.499535,0.015774,183,0.381922,R,R				

DWG266,A02R2701,E,6.176888,29.497055,0.015906,173,0.296647,R,R				
DWG267,A02R2701,E,5.627901,25.499929,0.013227,174,0.285581,R,R				
DWG268,SC-E-107667,E,9.339972,24.538078,0.032239,242,0.417207,R,R				
DWG269,SC-E-352151,E,13.96107,58.787571,0.088224,469,0.577373,R,R				
DWG270,SM-E-106987,E,5.606955,6.122527,0.011066,70,0.238012,A,A				
DWG271,SC-D-2799352,D,11.124844,100,0.132801,871,1.516797,R,R				
DWG272,SM-D-422468,D,15.962815,100,0.324315,1945,2.345663,R,R				
DWG273,SM-D-425566,D,14.522864,88.858353,0.124541,1268,0.991827,R,R				
DWG274,SM-D-447166,D,10.876871,100,0.414556,3258,3.15958,R,R				
DWG275,SM-D-447167,D,6.344103,74.209969,0.038149,473,0.680662,R,R				
DWG276,SM-D-447316,D,7.058271,100,0.094151,1777,1.919308,R,R				
DWG277,SM-D-498259,D,8.452272,100,0.178631,2550,2.243908,R,R				
DWG278,SM-D-498259,D,20.323046,100,0.642936,3242,3.145704,R,R				
DWG279,SC-E-64667,E,1.030478,100,0.078578,1422,11.118733,R,R				
DWG280,SC-E-726621,E,2.849459,100,0.134261,1580,5.522414,R,R				
DWG281,SC-E-73118,E,2.3371,100,0.158704,4405,9.785985,R,R				
DWG282,SM-E-106987,E,2.081378,100,0.130789,3085,8.44092,R,R				
DWG283,SM-E-115852,E,1.180709,100,0.080111,1863,9.798631,R,R				
DWG284,SM-E-115921,E,3.251258,100,0.216343,2677,9.457154,R,R				
DWG285,SM-E-1159212,E,1.609179,100,0.110845,1019,6.661205,R,R				
DWG286,74J658000,E,2.41532,56.03532,0.014522,247,0.315342,R,R				
DWG287,A02R2701,E,0.575348,50.536636,0.005826,121,0.940963,R,R				
DWG288,SM-E-106987,E,18.591982,100,0.328996,2676,2.360526,R,R				
DWG289,SC-D-2799351,E,1.221529,100,0.105767,1371,5.96413,R,R				
DWG290,SC-D-2799391,E,0.843095,100,0.09387,906,7.737011,R,R				
DWG291,SM-D-4255981,E,1.061453,100,0.114491,1132,6.730853,R,R				
DWG292,SM-D-4471651,E,1.575827,100,0.126727,1555,6.726611,R,R				
DWG293,74J658000,E,0.696514,79.698448,0.043403,1359,2.407813,R,R				
DWG294,SC-E-3521511,E,1.896252,70.960655,0.100287,549,3.203136,R,R				
DWG295,SC-E-6602571,E,0.789759,100,0.073722,741,6.162722,R,R				
DWG296,3100109-007,A,3.806417,100,0.599345,1703,17.017881,R,R				
DWG297,1071010,B,7.677561,100,0.647115,4297,17.382635,R,R				
DWG298,206803-00,B,5.887017,100,0.297831,2550,10.873835,R,R				

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DEFENSE TECHNICAL INFORMATION CENTER

File,Drawing No.,Size,Fill Factor,App. Blk. Orph. Rat.,Visual A/R,Auto A/R				
D002R001,IL00-1312515VOL3,B,7.352307,0.070742,A,R				
D002R002,IL00-1312515VOL3,B,6.335186,0.153441,A,R				
D002R003,IL00-1312515VOL3,B,5.610457,0.054095,A,A				
D002R006,IL00-1312515VOL3,B,4.032385,0.034762,A,A				
D002R012,IL00-1312515VOL3,B,5.614075,0.059583,A,A				
D002R016,IL00-1312515VOL3,B,7.28081,0.113435,A,R				
D002R020,IL00-1312515VOL3,B,7.00212,0.141394,A,R				
D002R022,IL00-1312515VOL3,B,5.002016,0.050924,A,A				
D002R023,IL00-1312515VOL3,B,5.685689,0.055198,A,A				
D002R029,IL00-1312515VOL3,B,3.470268,0.039348,A,A				
D002R036,IL00-1312515VOL3,B,4.477413,0.041724,A,A				
D003R010,PSP31-15-2326,B,15.39006,0.01095,A,A				
D003R020,PSP31-15-2422,C,6.768076,0.0126,A,A				
D003R027,PSP31-15-2680,C,7.712345,0.030463,A,A				
D003R030,PSP31-15-2796,C,16.273325,0.023797,A,A				
D003R042,PSP365-747,C,13.884515,0.015434,A,A				
D003R049,PSP5-1-1000-20,C,11.490644,0.043109,A,A				
D003R052,PSP5-1-1000-30,C,13.999292,0.012235,A,A				
D003R053,PSP5-1-1000-30,C,11.616861,0.04525,A,A				
D003R056,PSP5-1-1002,B,12.437151,0.013775,A,A				
D003R059,PSP5-1-1007,C,5.311427,0.02772,A,A				
D003R072,PSP5-19-9309,B,12.424453,0.015548,A,A				
D003R076,PSP5-19-9393-40,B,12.75789,0.012845,A,A				
D003R090,PSP5-19-9456,B,12.263727,0.014863,A,A				
D003R100,PSP5-19-9493,B,12.55155,0.014118,A,A				
D003R119,10511062,C,6.416109,0.013896,A,A				
D003R120,10511230,C,6.052509,0.01069,A,A				
D003R121,10511328,E,8.358081,0.031195,A,A				
D003R122,10511580,E,3.844181,0.019867,A,A				
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D012R051,MSMIS-16066,C,6.673806,0.052982,A,A					
D012R052,MSMIS-18734,B,4.188289,0.024745,A,A					
D012R060,MSMIS-19313,C,7.653867,0.016978,A,A					
D012R061,MSMIS-19313,C,8.514722,0.022004,A,A					
D012R062,MSMIS-19313,C,9.03038,0.017558,A,A					
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D012R065,MSMIS-19313,C,10.335995,0.025481,A,A					
D012R066,MSMIS-19313,C,7.611057,0.027274,A,A					
D012R067,MSMIS-19313,C,7.163682,0.017618,A,A					
D012R068,MSMIS-19313,C,7.256814,0.024473,A,A					
D012R069,MSMIS-19313,C,6.429782,0.017197,A,A					
D012R087,MSMIS-19914,C,9.223366,0.013013,A,A					
D012R096,MSMIS-20007,C,5.854512,0.011402,A,A					
D012R119,MSMIS-21569,C,5.593282,0.00994,A,A					
D012R130,MSMIS-26144,A,5.699015,0.013086,A,A					
D012R150,MSMIS-26148,A,14.288998,0.040625,A,A					
D012R160,MSMIS-26150,A,13.960724,0.039017,A,A					
D012R170,MSMIS-26151,A,10.133295,0.021098,A,A					
D012R190,MSMIS-26190,A,8.638045,0.02412,A,A					
D012R195,MSMIS-26190,A,3.939189,0.032768,A,A					
D012R220,MSMIS-26236,A,14.063833,0.033356,A,A					
D012R228,MSMIS-26332,C,5.559942,0.053353,A,A					
D012R230,MSMIS-26332,C,5.624756,0.051781,A,A					
D012R232,MSMIS-26332,C,4.942193,0.05722,A,A					

D012R238,MSMIS-26903,A,15.592829,0.140357,A,R					
D012R239,MSMIS-26903,A,13.043753,0.048262,A,A					
D012R240,MSMIS-26903,A,11.096527,0.048398,A,A					
D012R250,MSMIS-26903,A,10.06844,0.056016,A,A					
D012R254,MSMIS-26903,A,12.172102,0.069802,A,R					
D012R260,MSMIS-28994,C,4.113556,0.044651,A,A					
D012R270,AMMIS-30289(1),C,4.836329,0.062945,A,R					
D012R279,MSMIS-41167,C,2.096214,0.012632,A,A					
D012R280,MSMIS-41167,C,2.329354,0.015513,A,A					
D012R281,MSMIS-41167,C,2.28396,0.011544,A,A					
D012R282,MSMIS-41167,C,2.371445,0.008673,A,A					
D012R283,MSMIS-41167,C,2.543745,0.010379,A,A					
D012R284,MSMIS-41167,C,4.090218,0.011964,A,A					
D012R285,MSMIS-41167,C,2.550398,0.012486,A,A					
D012R286,MSMIS-41167,C,5.066511,0.014843,A,A					
D012R287,MSMIS-41167,C,4.189808,0.010431,A,A					
D012R288,MSMIS-41167,C,2.122046,0.008499,A,A					
D012R289,MSMIS-41167,C,4.282922,0.011234,A,A					
D012R290,MSMIS-41167,C,4.54004,0.010363,A,A					
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D012R294,MSMIS-41167,C,3.120261,0.013667,A,A					
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D012R296,MSMIS-41167,C,3.624571,0.014985,A,A					
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D012R298,MSMIS-41167,C,2.883335,0.008965,A,A					
D012R299,MSMIS-41167,C,5.368211,0.026911,A,A					
D012R300,MSMIS-41167,C,3.725467,0.010684,A,A					
D012R302,MSMIS-41167,C,3.060156,0.010973,A,A					
D012R303,MSMIS-41167,C,3.414299,0.01401,A,A					
D012R304,MSMIS-41167,C,4.396671,0.013398,A,A					
D012R305,MSMIS-41167,C,3.119506,0.009793,A,A					

D012R306,MSMIS-41167,C,2.842991,0.019254,A,A					
D012R307,MSMIS-41167,C,3.670562,0.012376,A,A					
D012R308,MSMIS-41167,C,3.809151,0.011648,A,A					
D012R309,MSMIS-41167,C,3.421129,0.013782,A,A					
D012R320,MSMIS-41167,C,2.341739,0.014023,A,A					
D012R321,MSMIS-41167,C,2.387315,0.012978,A,A					
D012R322,MSMIS-41167,A,1.069808,0.000919,A,A					
D012R330,MDMPD-1506,C,5.759424,0.014843,A,A					
D012R332,AMMPD-1506(2),C,2.07585,0.021034,A,A					
D012R337,NTMPD-3348(2),A,3.899039,0.014634,A,A					
D012R346,AMMPD-7011(2),B,4.743131,0.013505,A,A					
D012R360,MDMPD-9222,C,7.338582,0.030062,A,A					
D012R361,MDMPD-9222,C,5.914706,0.037476,A,A					
D012R370,MDMPD-9222,C,6.212884,0.022205,A,A					
D012R375,SM-A-773492,A,8.277423,0.055483,A,A					
D012R376,SM-A-773492,A,11.933327,0.129987,R,R					
D012R377,SM-A-773492,A,7.45429,0.082973,A,R					
D012R379,SM-C-772101,C,7.04247,0.00889,A,A					
D012R387,SM-C-773464,C,5.104961,0.041038,A,A					
D012R402,SM-C-808814,C,6.394166,0.00921,A,A					
D012R406,SQSQAP10279644,C,7.389101,0.04306,A,A					
D012R408,SQSQAP11070432,A,21.504276,0.089986,A,R					
D012R409,SQSQAP11070432,A,16.768255,0.063475,A,R					
D012R410,SQSQAP11070432,A,16.380468,0.053952,A,A					
D012R411,SQSQAP11070432,A,13.523617,0.249841,R,R					
D012R412,SQSQAP13007014,C,6.671721,0.052438,A,A					
D012R420,10210438,C,4.559118,0.005147,A,A					
D012R430,PL10219503,B,2.528493,0.02672,A,A					
D012R435,PS10225669,A,4.748959,0.004782,A,A					
D012R445,PL10237754,B,3.283963,0.013831,A,A					
D012R470,10280223,E,2.881405,0.012554,A,A					
D012R472,10662203,B,4.054557,0.035133,A,A					
D012R474,10694546,F,4.719241,0.007803,A,A					

D012R480,PL10695173,B,4.628077,0.068138,R,R					
D012R481,11069766,C,6.014238,0.09587,A,R					
D012R482,11069767,F,4.076704,0.008262,A,A					
D012R483,11069769,F,3.367218,0.003085,A,A					
D012R485,11070318,C,4.574599,0.025697,A,A					
D012R487,11070431,E,13.317873,0.010698,A,A					
D012R489,IL11070432,C,10.212032,0.020604,A,A					
D012R493,EC11070573,A,16.269369,0.065945,A,R					
D012R507,EC11070573,A,27.154217,0.422835,R,R					
D012R514,ED11070573,A,6.585402,0.010543,A,A					
D012R533,ED11070573,A,20.931147,0.045561,A,A					
D012R544,OI11070573,A,18.703581,0.060936,R,R					
D012R566,11071958,F,4.482929,0.001902,A,A					
D012R570,11176177,C,11.825243,0.09348,R,R					
D012R574,11450501,F,5.027212,0.046785,R,A					
D012R575,11450501,F,8.585497,0.200112,R,R					
D012R576,11450501,F,2.984891,0.010924,A,A					
D012R579,11450546,C,4.722565,0.066687,A,R					
D012R580,11450549,C,6.439871,0.056268,A,A					
D012R584,PL11557908,B,6.619586,0.057661,A,A					
D012R585,PL11557908,B,4.979042,0.057586,A,A					
D012R588,11558005,E,4.583309,0.064177,R,R					
D012R593,13062019,C,2.723146,0.004094,A,A					
D013R001,SQ12292392,B,5.491799,0.010066,A,A					
D013R040,SQ12292410,B,6.247076,0.010077,A,A					
D013R060,SQ12292444,B,3.030245,0.005355,A,A					
D013R070,SQ12292564,B,2.485823,0.038906,A,A					
D013R090,SQ12292568,B,8.354137,0.182126,A,R					
D013R101,114E5857,E,9.460881,0.043233,A,A					
D013R130,7-M621300011,C,12.332316,0.000059,A,A					
D013R140,7-311B24174,C,7.754965,0.000064,A,A					
D013R162,114S1867,E,2.585112,0.044126,A,A					
D013R170,PL7-311642403,C,5.317619,0.056045,A,A					

D013R192,114S2413,E,5.056825,0.079137,R,R					
D013R201,PL7-311830204,C,3.744936,0.036283,A,A					
D014R010,DRC-C-H501505P102731,C,9.818698,0,A,A					
D014R030,DRC-C-H6006,C,12.012567,0.000086,A,A					
D014R050,DRC-C-H6006,C,10.567795,0,A,A					
D014R070,DRC-C-H6006,C,11.950058,0,A,A					
D014R100,DRC-C-H6013,C,8.444383,0.000086,A,A					
D014R121,DRC-C-H6013,C,5.520601,0.000027,A,A					
D014R122,DRC-N-H5001P1,C,11.823896,0.000027,A,A					
D014R143,DRC-N-H5001P2,C,10.604272,0.000051,A,A					
D014R165,DRC-N-H5041P1,C,12.74858,0.000052,A,A					
D014R167,DRC-N-H5041P1,C,12.705322,0.000051,A,A					
D014R186,HP11-25,C,10.469117,0.000074,A,A					
D014R190,HP11-25,B,8.157465,0.015494,A,A					
D014R201,HP14-48/4,B,7.319518,0.032147,A,A					
D014R202,HP6-18,C,6.190946,0.203885,R,R					
D014R220,ID20-11024,C,5.443028,0.000062,A,A					
D014R231,ID20-11024,C,5.432836,0.000047,A,A					
D014R233,ID20-11024,C,4.94727,0.000048,A,A					
D015R001,12007400,F,5.648582,0.003851,A,A					
D015R022,PS12007818,A,12.260326,0.006088,A,A					
D015R030,SQ12912385,B,9.447066,0.007274,A,A					
D015R042,12007855,F,4.532683,0.004382,A,A					
D015R066,SQ12913899,B,8.74589,0.015507,A,A					
D015R074,123-1-55,C,5.907748,0.014672,A,A					
D015R095,DL123-1-801,B,12.20461,0.007484,A,A					
D015R107,12918297,E,0.190171,0.018844,R,R					
D015R135,123-1-824,B,7.156483,0.008182,A,A					
D015R138,LD13221E6850,A,9.715292,0.021805,A,A					
D015R180,LM136-10-24,C,12.135573,0.003381,A,A					
D015R200,136-11-401,C,2.615403,0.003748,A,A					
D015R243,LM136-25-4,C,10.685763,0.00685,A,A					
D015R257,PL136-27-260,B,14.323081,0.015905,A,A					

D015R277,136-28-41,C,2.386078,0.007812,A,A					
D015R290,136-29-5,C,9.157011,0.006772,A,A					
D015R300,136-41-1952,B,4.496979,0.003121,A,A					
D015R327,PL136-41-1968,B,9.705283,0.004026,A,A					
D015R347,136-41-1987,B,6.117203,0.019382,A,A					
D015R349,PL136-41-1988,C,12.337903,0.003757,A,A					
D015R390,5-15-3022,B,7.579512,0.007526,A,A					
D015R406,SQ5-15-3068,A,7.851327,0.009092,A,A					
D015R420,5-19-11083,F,3.789501,0.00208,A,A					
D015R444,7550190,B,6.932902,0.001423,A,A					
D015R447,DP7550212,C,4.713667,0.004381,A,A					
D015R449,DP7550215,B,5.873587,0.005651,A,A					
D015R450,DP7550217,B,5.399264,0.002781,A,A					
D015R481,PL7550284,A,10.809069,0.009785,A,A					
D015R487,DX7550289,C,6.427983,0.004549,A,A					
D015R503,PL7551811,B,5.217088,0.006082,A,A					
D015R520,7551818,E,2.650935,0.008402,A,A					
D015R540,7551830,F,3.326332,0.003555,A,A					
D015R558,DL9206978,B,6.922249,0.006304,A,A					
D015R580,9230058,B,5.96023,0.005573,A,A					
D015R587,9234710,E,4.99713,0.006896,A,A					
D016R001,HP11-25,C,10.469117,0.000074,A,A					
D016R015,HP14-48/4,C,13.470604,0.000092,A,A					
D016R017,HP6-18,C,6.190946,0.203885,R,R					
D016R018,HS4390,C,5.688688,0.075964,A,R					
D016R020,HS4787,C,12.38561,0.000057,A,A					
D016R023,ID20-11024,C,3.316985,0.000045,A,A					
D016R030,ID20-11024,C,7.85293,0.000051,A,A					
D016R045,ID20-11024,C,5.83395,0.000032,A,A					
D017R001,BPSFWG4404,B,5.436126,0.020186,A,A					
D017R005,134AV81301,E,5.466228,0.018568,A,A					
D017R009,BPSFW4007,B,7.71365,0.023111,A,A					
D017R015,134AV81301,E,7.925699,0.027323,A,A					

D017R019,BPSFW4012,B,11.663931,0.008053,A,A					
D017R022,BPSFW4019,B,6.423697,0.004623,A,A					
D017R029,BPSFW4019,B,6.769119,0.012204,A,A					
D017R038,BPSFW4038,B,8.748559,0.015039,A,A					
D017R048,BPSFW4043,B,11.021193,0.010645,A,A					
D017R054,134AV81301,E,20.401449,0.04541,A,A					
D017R077,PL134BM80093,B,9.460058,0.008173,A,A					
D017R100,134EC30021,E,7.618758,0.062884,A,R					
D017R104,PL134EL80008,C,7.629727,0.011828,A,A					
D017R107,BPS4018,B,6.131896,0.007313,A,A					
D017R116,BPS4036,B,6.669576,0.0109,A,A					
D017R147,BPS4050,B,10.387903,0.019826,A,A					
D017R149,134P80008,E,13.510559,0.042388,A,A					
D017R158,BPS4140,B,6.664033,0.010285,A,A					
D017R185,134SCF104,E,9.973162,0.048324,A,A					
D017R216,134SCP114,E,10.81109,0.046697,A,A					
D017R217,BPS4158,B,5.93293,0.016595,A,A					
D017R223,BPS4162,B,5.701358,0.015797,A,A					
D017R239,134SC10280,E,12.559258,0.075324,A,R					
D017R241,BPS4163,B,7.978365,0.013561,A,A					
D017R249,134SEAV14096,E,6.390713,0.073438,A,R					
D017R256,7SBPS4163,B,5.309544,0.010464,A,A					
D017R274,BPS4310,B,6.124949,0.010512,A,A					
D017R292,369A1800,F,7.05592,0.013523,A,A					
D017R300,BPS4312,B,11.368655,0.013998,A,A					
D017R310,BPS4407,B,11.890286,0.015119,A,A					
D017R319,BPS4425,B,6.35729,0.007957,A,A					
D017R348,7SBPS4426,B,6.496046,0.019306,A,A					
D017R357,BPS4451,B,5.794076,0.014289,A,A					
D017R371,BPS4470,B,6.338387,0.014809,A,A					
D017R376,369A4104,E,6.508744,0.031855,A,A					
D017R386,BPS4530,B,5.906243,0.013735,A,A					
D017R401,BPS4531,B,6.138464,0.007597,A,A					

D017R409,DPS102,B,8.683136,0.010208,A,A
D017R424,369A7347,F,5.438271,0.010624,A,A
D017R445,7-M11B28025,E,6.726612,0.000014,A,A
D017R449,DPS11,B,8.826485,0.017522,A,A
D017R457,7-M11122004,E,5.443649,0.000023,A,A
D017R467,7-M11160002,E,7.608095,0.00002,A,A
D017R484,DPS11,B,7.82524,0.016151,A,A
D017R519,DPS58,B,4.995099,0.015183,A,A
D017R547,DPS77,B,8.734399,0.016321,A,A
D017R578,PL7-311642403,C,5.317619,0.056045,A,A
D017R611,204-060-687,C,6.083877,0.025286,A,A
D017R625,PL7-311670322,C,4.975003,0.070609,A,R
D017R635,204-060-730,C,3.780254,0.038721,A,A
D017R650,DL7-311830335,B,3.504949,0.061186,A,R

APPENDIX C
IDENTIFICATION RECOGNITION RESULTS

This appendix gives detailed results for the following two cases of identification recognition testing for the vendors tested.

1. ID Date Set 2 existing DSREDS/EDCARS Data:
   - MCC results,
   - Nestor results,
   - NTI results, and
   - VisionShape results.

1. ID Date Set 3 "High Quality" Data:
   - MCC results,
   - Nestor results,
   - NTI results, and
   - VisionShape results.

MCC Data Set 2 Test Results

	Original	Recognized		Original	Recognized		Original	Recognized		Original	Recognized	
	SIZE	SIZE	Error	CAGE #	CAGE #	Error	DRAWING #	DRAWING #	Error	Sheet	Sheet	Error
D001R001	B	B	0	70210	7O2IO	3	EMS94750	ENS9475O	2	1 OF 3	I 8 3	2
D001R042				70210	7OZTO	4	WBS18	N8SI8	3	1 OF 75	N 8. 7	4
D001R070				70210	7O2IO	3	WBS18	WBSIO	2	29	29	0
D003R130	C	C	0	19204	I92O4	2	11010483	IIOIO483	5	1 OF 1	I OE I	3
D003R133	D	D	0	19204	X92O4	2	11020141	IIO2OI4I	6	1 OF 1	IOFI	2
D004R247	K		1	59678		5	11020150		8	1 OF 2		4
D004R273	A	A	0	80063	8OO6	3	SM-A-773492	SM-A-773AO2	2	1 OF 4	IOFA	2
D004R280	C	C	0	80063	8OO63	2	SM-C-773163	SMI-CFTT3I63	4	2	2	0
D004R330	D	D	0	18876	I8876	1	10215638	IO2I563	4	1 OF 1	I OE I	3
D005R229	C	C	0	80063	8OO63	2	SM-C-772101	SN-C-772IOI	4	1 OF 2	I OF 2	1
D005R300	F	F	0	55717	SS7I	4	10250675	IO25O67	3	2	Z	0
D008R003	A	A	0	19200	I92OO	3	12714307	I27I43O7	3	2	2	0
D008R137	F	F	0	19200	IO2O	4	12912040	I29I2O4	4			
D008R255	C	C	0	19200	I92OO	3	12912209	I29I22O9	3			
D008R334	A	A	0	19200	I92OO	3	12912254	I2OI2254	3	1 OF 5	IOI5	3
D009R002.	C	C	0	19200		5	12913746	293T4	4			
D009R055	D		0	19200		5	12927330		8			
D009R104	B	B	0	19205	IO2O5	3	5013611	5OI36II	4	1 OF 1	L3P	4
D009R150	B	B	0	19204	392O4	2	7161257	7I6I257	2	1 OF 1	I OF I	2
D009R165	C		1	19203		5	7549268	7549268	0			
D009R210	E		1	19200	IO2OO	4	8293051		8	2 OF 7		4
D009R275	B	B	0	19200	I92ORO	3	8626392	B626392	1	1 OF 1	I OF I	2
D010R002	D	D	0	19200	I92OO	3	12564909	I25649O9	2			
D010R009	F		1	19200		5	12576397	I2576397	1			
D010R020	D	D	0	19200	I92WUMO	3	12596328	I2596328	1	2	2	0
D010R022	D	D	0	19200	I92OO	3	12596328	I2596328	1	8	8	0
D010R027							12596848	I259684	2			
D010R028	K	K	0	19200	I92OO	3	12596848	I2596848	1	1 OF 2		4
D010R045	A	A	0	19200	S92ORO	3	12710085	I27IOO85	4	1 OF 17	IF I7	5
D011R010	C	C	0	78286	78286	0	64070-85009	64OO-C5OOO	7	2 OF	2 N	2
D011R379	C	C	0	80063	8OO63	2	SM-C-772101	SN-C-772IOI	4	1 OF 2	I OF 2	1
D011R420	C	C	0	18876	I8876	1	10210438	IO2IOO38	5	1 OF 1	IOE I	3
D013R001				19207		5						
D013R101	J		1	77272		5	J14E5857		8			
D013R130	B		1	O2731		5	7-M62300011		11	1 OF 1		4

MCC Data Set 2 Test Results

D013R140				o2731		5	7-311B24174		11	4		1
D015R001	F	F	0	19204	IS2O4	3	12007400	I2OO74OO	5	5 OF 6		4
D015R021	C	C	0	19204	S92O4	2	12007863	I2OO78I5	5	OF	OF	0
D015R024	C	C	0	19204	392O4	2	12009857	I2OO7 82O	6	OF	OF	0
D015R035	C	C	0	19200		5	12007853	I2O O7853	4			
D015R042	F	F	0	19204	I92O4	2	12007855	I2OO7855	3	3 OF 4	3OI4	1
D015R049	C	C	0	19204	I92O4	2	12007853		8	OF		2
D015R051	C	C	0	19204	S92O4	2	12007851	I2OO7855	4	OF	OF	0
D015R064	C	C	0	19204	S92O4	2	12007863	I2OO7863	3	OF	OE	1
D015R074	C	C	0	81361		5	C123-1-55	CI23/55	4			
D015R080	B	B	0	81361	8I36I	2	B123-1-62	8/23-I-62	3			
D015R095	A	A	0	81361	8I36I	2	DL123-1-801	DL I23-I-8OI	4	6 OF 9	6 OE S	2
D015R109	C	C	0	19200	I92O	3	12922205	I2O222O5	3			
D015R119	B	B	0	81361		5	B123-1-81	8I23-I-8/	4			
D015R124	C	C	0	81361	8I36I	2	C123-1-817	CI23--8I6	3			
D015R126	C	C	0	81361		5	C123-1-818		10			
D015R135	B	B	0	81361	8I36I	2	B123-1-824	BI23-I-824	2			
D015R180	C	C	0				136-10-24	I36IO-24	4			
D015R257	B	B	0	81361	8I36I	2	PL-136-27-260		13	2 OF 4		4
D015R260	E	E	0	81361	8I36	2	136-27-261	I36-27-26O	2	1 OF 1	IO	3
D015R263	E	E	0	81361	8I36I	2	136-27-262	I36-27262	2	2 OF 2	S2	3
D015R282	B	C	1	81361	8I36I	2	B123-1-62		9			
D015R300	B	B	0	81361	8I36I	2	136-41-1952	I36-4I-I952	3	1 OF 1	I OFI	2
D015R327	B	8	1	81361	8I36I	2	PL-136-41-1968	PLI36-4I-I96B	5	2 OF 2	2 DF 2	1
D015R390	B		1	81361	8I356I	3	B5-15-3022	B5-/5-3O22	2			
D015R406	C		1				5-15-3068		9	1 OF 1		4
D015R420	D	D	0	81361	8I365	2	5-19-11083	5I9 IO83	5			
D015R487	C	C	1	19204	I92O4	2	7550289	755O28	2	1 OF 1	I OF	2
D015R520	F	F	0	19204	I92O4	2	7551818	755I8I	3	6 OF 10	6 OI IO	3
D015R540	D	D	0	19204	I92O4	2	7551830	75583O	2	1 OF 1	OF I	2
D015R587	F	F	0	19203	I92O8	2	9234710		7	1 OF 2		4
D016R015				o2731	O278I	3				3 OF 7		4
D016R020				o2731		5	HS4787		6	2 OF 2		4
D017R149							134P80008	I24P8OOO8	6	1	I	1
D017R216	J	J	0	26512		5	134SCP114		9			
D017R239				26512	2ONIE	4	134CS10280	I34C SIO28O	4	1	I	1
D017R292	D	D	0	o2731	O273I	1	369A1800	369A8OO	3	1 OF 1	I OF I	2

MCC Data Set 2 Test Results

D017R477	B	E	1	o2731		5	7-M62300011		11	1 OF 1		4
Total			12			208			319			110
							Total Char. Errors	649				
							Total Characters	1191				
							% Char. Correct	46%				
							Total Field Errors	192				
							Total Fields	254				
							% Fields Correct	24%				

Nestor Data Set 2 Test Results

	Original SIZE	Recognized SIZE	Error	Original CAGE #	Recognized CAGE #	Error	Original DRAWING #	Recognized DRAWING #	Error	Original Sheet	Recognized Sheet	Error
D001R001	B	B	0	70210	70210	0	EMS94750	IMS9A/5O	4	1 OF 3	3	3
D001R042				70210	7021O	1	WBS18	WBS18	0	1 OF 75		5
D001R070				70210	7O21O	2	WBS18	WESL8	2	29	29	0
D003R130	C	C	0	19204	192G	2	11010483	LLONO	8	1 OF 1		4
D003R133	D	D	0	19204	19204	0	11020141	O2O4	6	1 OF 1		4
D004R247	K	K	0	59678	5967B	1	11020150		8	1 OF 2		4
D004R273	A	A	0	80063	8OO63	2	SM-A-773492	SMA773492	2	1 OF 4	OF4	1
D004R280	C	C	0	80063	80063	0	SM-C-773163	6M-C-7	6	2	2	0
D004R330	D	D	0	18876	L8876	1	10215638	LO2L5638	3	1 OF 1		4
D005R229	C	C	0	80063	80O63	1	SM-C-772101	SMC772O	5	1 OF 2	OF2	1
D005R300	F	F	0	55717	S57I7	2	10250675	675	4	2	2	0
D008R003	A	A	0	19200	L92Q	3	12714307	27L43O7	3	2	2	0
D008R137	F	F	0	19200		5	12912040		8			
D008R255	C	C	0	19200	L92Q	4	12912209	29L22O	4			
D008R334	A	A	0	19200	19200	0	12912254	129122M	2	1 OF 5	1OF5	0
D009R002.	C	C	0	19200	L92Q	3	12913746		8			
D009R055	D	D	0	19200	1G2	3	12927330	12V2733O	2			
D009R104	B	B	0	19205	192O5	1	5013611	5ON36LP	4	1 OF 1	LOFT	2
D009R150	B	B	0	19204	192O4	1	7161257	716A257	1	1 OF 1		4
D009R165	C	C	0	19203	L9203	1	7549268	754926	1			
D009R210	E	E	0	19200	192OG	2	8293051		7	2 OF 7		4
D009R275	B	B	0	19200	L92W	3	8626392	86Z6392	1	1 OF 1		4
D010R002	D		1	19200	1G2GC	3	12564909	12564S0S	2			
D010R009	F	F	0	19200	1G20O	2	12576397		8			
D010R020	D	8	1	19200	192GG	2	12596328		8	2	2	0
D010R022	D	0	1	19200	N9200	1	12596328		8	8	8	0
D010R027							12596848		8			
D010R028	K	K	0	19200	L92OO	3	12596848		8	1 OF 2		4
D010R045	A	A	0	19200	I921	3	12710085	L270O85	2	1 OF 17	7	3
D011R010	C	C	0	78286	78286		64070-85009	64D70	7	2 OF		3
D011R379	C	C	0	80063	80O63	1	SM-C-772101	SMC772O	5	1 OF 2	OF2	1
D011R420	C	C	0	18876	L8876	1	10210438	LO2LO438	4	1 OF 1		4
D013R001				19207		5						
D013R101	J	J	0	77272	772Z	2	J14E5857	JJI4	7			
D013R130	B	B	0	O2731		5	7-M62300011	7SM6F3PD	7	1 OF 1		4

Nestor Data Set 2 Test Results

D013R140					o2731	O27G4	3	7-311B24174	73TTB24T7N	5	4	4	0
D015R001	F	F		0	19204	L92O4	2	12007400	12OO74OO	4	5 OF 6	6	3
D015R021	C	C		0	19204	I92O4	2	12007863	I2OO7	4	OF		2
D015R024	C	C		0	19204	N9204	1	12009857	I20O7820	3	OF		2
D015R035	C	C		0	19200		5	12007853	N2OO7853	3			
D015R042	F	F		0	19204	I092O	3	12007855	N2OO7855	3	3 OF 4	3OE4	1
D015R049	C	C		0	19204	L92W	3	12007853		8	OF		2
D015R051	C	C		0	19204	I9204	1	12007851	L2OO7857	4	OF	OF	0
D015R064	C	C		0	19204	N92O4	2	12007863	L2OO7863	3	OF		2
D015R074	C	C		0	81361	81M1	2	C123-1-55		9			
D015R080	B	B		0	81361	81631	0	B123-1-62	B23--6G	3			
D015R095	A	A		0	81361	81M1	2	DL123-1-801	DL423-VS	6	6 OF 9	6Q9	2
D015R109	C		5	1	19200		5	12922205	129222	2			
D015R119	B	B		0	81361	81361	0	B123-1-81		9			
D015R124	C	C		0	81361	81361	0	C123-1-817	C773-4-8L6	5			
D015R126	C	C		0	81361		5	C123-1-818		9			
D015R135	B	B		0	81361	81361	0	B123-1-824	BL23-L824	3			
D015R180	C	C		0				136-10-24		9			
D015R257	B	B		0	81361	8YXZ	4	PL-136-27-260	13627260	5	2 OF 4	2OF4	0
D015R260	E	E		0	81361	81361	0	136-27-261	436-27-26	2	1 OF 1		4
D015R263	E	E		0	81361	81361	0	136-27-262	I36-L7-26L	3	2 OF 2	2OF2	0
D015R282	B	C		1	81361	81361	0	B123-1-62	C136-29-1	6			
D015R300	B	B		0	81361	81361	0	136-41-1952	364952	5	1 OF 1		4
D015R327	B	B		0	81361	836	2	PL-136-41-1968	P364968	6	2 OF 2	20F2	1
D015R390	B	B		0	81361		5	B5-15-3022	B5E53022	3			
D015R406	C	C		0				5-15-3068	5153068	2	1 OF 1	4	
D015R420	D	D		0	81361	81631	0	5-19-11083	5-IG-O83	5			
D015R487	C	C		0	19204	I9204	1	7550289	755O289	1	1 OF 1	OFL	2
D015R520	F	F		0	19204	L9204	1	7551818	75518L8	1	6 OF 10	6OELO	3
D015R540	D	D		0	19204	19204	0	7551830	755L83O	2	1 OF 1	OFL	2
D015R587	F	F		0	19203	19203	0	9234710	92347LO	2	1 OF 2	OF2	1
D016R015					o2731	o2731	0				3 OF 7	3OT7	1
D016R020					o2731	0273E	1	HS4787	HS4RP7	1	2 OF 2	2OP2	1
D017R149								134P80008	L34P8OOO8	4	1	L	1
D017R216	J	J		0	26512	26	3	134SCP114	18ASCP214	3			
D017R239					26512	26512	0	134CS10280	D34S4CSLO28O	5	1		0
D017R292	D	D		0	o2731	O2731	1	369A1800	3CO	7	1 OF 1	OF	2

Nestor Data Set 2 Test Results

D017R477	B	B	0	o2731	O2	3	7-M62300011	7SM6F3PD	8	1 OF 1		4
Total			5			123			326			99
							Total Char. Errors	553				
							Total Characters	1191				
							% Char. Correct	54%				
							Total Field Errors	165				
							Total Fields	254				
							% Fields Correct	35%				

NTI Data Set 2 Test Results

	Original	Recognized	46	Original	Recognized		Original	Recognized		Original	Recognized	
	SIZE	SIZE	Error	CAGE #	CAGE #	Error	DRAWING #	DRAWING #	Error	Sheet	Sheet	Error
D001R001	B	B	0	70210	7C02C10	2	EMS94750	EMS9Q75Q	2	1 OF 3	1 OF 3	0
D001R042				70210	70210	0	WBS18		5	1 OF 75	1 OF 75	0
D001R070				70210		5	WBS18		5	29		2
D003R130	C	C	0	19204	192M	2	11010483	11010483	0	1 OF 1	1G1	2
D003R133	D	D	0	19204	19804	1	11020141	11020141	0	1 OF 1	1G1	2
D004R247	K		1	59678		5	11020150		8	1 OF 2		4
D004R273	A	A	0	80063	80063	0	SM-A-773492	SM-A4773492	1	1 OF 4	1OF4	0
D004R280	C	C	0	80063	80063	0	SM-C-773163	SM-C-773163	0	2	2	0
D004R330	D		1	18876	18876	0	10215638	10215638	0	1 OF 1	1OFK	1
D005R229	C	C	0	80063	80063	0	SM-C-772101	SM-C-772101	0	1 OF 2	1 OF 2	0
D005R300	F	F	0	55717		5	10250675		8	2		1
D008R003	A	A	0	19200	192W	2	12714307	12714307	0	2		1
D008R137	F	F	0	19200	19200	0	12912040	12912040	0			
D008R255	C	C	0	19200	192W	2	12912209	12912209	0			
D008R334	A	A	0	19200	19200	0	12912254	12912254		1 OF 5	1 O1 5	1
D009R002.	C	C	0	19200		5	12913746		8			
D009R055	D		1	19200		5	12927330		8			
D009R104	B		1	19205	19205	0	5013611	5013611	0	1 OF 1	1 OF 1	0
D009R150	B	B	0	19204	19204	0	7161257		7	1 OF 1		4
D009R165	C	C	0	19203		5	7549268	7549268	0			
D009R210	E		1	19200		5	8293051		7	2 OF 7		4
D009R275	B	B	0	19200	19200	0	8626392	86R6392	1	1 OF 1	1 OF 1	0
D010R002	D		1	19200		5	12564909		8			
D010R009	F		1	19200		5	12576397		8			
D010R020	D		1	19200		5	12596328		8	2		1
D010R022	D		1	19200		5	12596328		8	8		1
D010R027							12596848		8			
D010R028	K		1	19200		5	12596848		8	1 OF 2		4
D010R045	A	A	0	19200		5	12710085		8	1 OF 17		4
D011R010	C		1	78286		5	64070-85009		11	2 OF		3
D011R379	C	C	0	80063	80063	0	SM-C-772101	SM-C-772101	0	1 OF 2	1 OF 2	0
D011R420	C	C	0	18876		5	10210438		8	1 OF 1	1 OF 1	0
D013R001				19207		5						
D013R101	J	5 J	1	77272	77272	0	J14E5857	J14EW5T	3			
D013R130	B		1	O2731		5	7-M62300011		11	1 OF 1		4
D013R140				o2731		5	7-311B24174		11	4		1
D015R001	F	F	0	19204	19204	0	12007400	12007400	0	5 OF 6		4
D015R021	C	C	0	19204	S92O4	2	12007863	I2OO78I5	5	OF	OF	0

NTI Data Set 2 Test Results

D015R024	C	C	0	19204	392O4	2	12009857	I2OO7 82O	6	OF	OF	0
D015R035	C	C	0	19200		5	12007853	I2O O7853	4			
D015R042	F	F	0	19204	I92O4	2	12007855	I2OO7855	3	3 OF 4	3OI4	1
D015R049	C	C	0	19204	I92O4	2	12007853		8	OF		2
D015R051	C	C	0	19204	S92O4	2	12007851	I2OO7855	4	OF	OF	0
D015R064	C	C	0	19204	S92O4	2	12007863	I2OO7863	3	OF	OE	1
D015R074	C	C	0	81361	81X1	2	C123-1-55	C12331455	2			
D015R080	B	B	0	81361	8I36I	2	B123-1-62	8/23-I-62	3			
D015R095	A	A	0	81361	81361	0	DL123-1-801	DL123-1-801	0	6 OF 9	6 OF 9	0
D015R109	C	C	0	19200	I92O	3	12922205	I2O222O5	3			
D015R119	B	B	0	81361		5	B123-1-81	8I23-I-8/	4			
D015R124	C	C	0	81361	8I36I	2	C123-1-817	CI23--8I6	3			
D015R126	C	C	0	81361		5	C123-1-818		10			
D015R135	B	B	0	81361	81361	0	B123-1-824	B123-1-824	0			
D015R180	C	C	0				136-10-24	136-10-24	0			
D015R257	B		1	81361		5	PL-136-27-260		13	2 OF 4		4
D015R260	E	E	0	81361	8I36	2	136-27-261	I36-27-26O	2	1 OF 1	IO	3
D015R263	E	E	0	81361	8I36I	2	136-27-262	I36-27262	2	2 OF 2	S2	3
D015R282	B	C	1	81361	8I36I	2	B123-1-62		9			
D015R300	B		1	81361		5	136-41-1952		11	1 OF 1		4
D015R327	B	B	0	81361	81361	0	PL-136-41-1968	PL-136-41-1968	0	2 OF 2	2 OF 2	0
D015R390	B	BX	1	81361		5	B5-15-3022	85-15-3022	1			
D015R406	C		1				5-15-3068		8	1 OF 1		4
D015R420	D	D	0	81361	81361	0	5-19-11083	5-19-11083	0			
D015R487	C	C	0	19204	19204	0	7550289	7550289	0	1 OF 1	1 OF 1	0
D015R520	F		1	19204		5	7551818		7	6 OF 10		5
D015R540	D	D	0	19204	19204	0	7551830	7551830	0	1 OF 1	1 OF 1	0
D015R587	F		1	19203		5	9234710		7	1 OF 2		4
D016R015				o2731	o2731	0				3 OF 7	3 OI 7	1
D016R020				o2731		5	HS4787		6	2 OF 2		4
D017R149							134P80008		9	1		1
D017R216	J		1	26512		5	134SCP114	1843SYCPP114	4			
D017R239				26512	26512	0	134CS10280		10	1	1	0
D017R292	D		1	o2731	o2731	0	369A1800	359A1800	1	1 OF 1		4
D017R477	B		1	o2731		5	7-M62300011		11	1 OF 1		4
			23			181			319			89
								Total Char. Errors		612		
								Total Characters		1191		
								% Char. Correct		49%		

NTI Data Set 2 Test Results

								Total Field Errors		164		
								Total Fields		254		
								% Field Correct		35%		

VisionShape Data Set 2 Test Results

	Original	Recognized		Original	Recognized		Original	Recognized		Original	Recognized	
	SIZE	SIZE	Error	CAGE #	CAGE #	Error	DRAWING #	DRAWING #	Error	Sheet	Sheet	Error
BLOCK021	B		1	56540	5-540	1	1071010	1071010	0	1 OF 1	1 - - 1	2
BLOCK022	B		1	63395	-3395	1	206803-00	206------	6	1 OF 1	1 - - 1	2
BLOCK027	A		1	25500		5	3100109-007	3100109-007	0	1 OF 79	1 -F 79	1
BLOCK044	B	B	0	80063		5	SM-B-389801	SM8--801	4	1 OF 3	1 OF 3	0
BLOCK045	B		1	80063		5	SM-B-389809		11	OF		2
BLOCK047	B		1	80063		5	SM-B-389809		11	OF		2
BLOCK050	B		1	80063		5	SM-B-389853		11	OF		2
BLOCK051	B	B	0	80063		5	SM-B-389853	S-8- - 853	7			
BLOCK052	B		1	80063		5	SM-B-389879	S-8- - 853	7	2 OF 2		5
BLOCK055	B		1	80063		5	SM-B-389879		11	1 OF 1		4
BLOCK060	B		1	80063		5	SM-B-389917	M---917	8			
BLOCK079	B	B	0	80063		5	SM-B-389801	SM - - M1	8			
BLOCK086	C		1	56540	5-540	1	1062001	06- -001	3	1 OF 1	1 O - 1	1
BLOCK089	C	C	0	80063	30063	1	SG-G-609601	_C609601	5			
BLOCK105	C	C	0	80063	30063	1	SM-C-563457	563457	5			
BLOCK107	C	C	0	80063	80063	0	SM-C-604977	5M-C-604-7	4			
BLOCK111	C	C	0	80063	_0063	1	SM-C-621535	621535	5			
BLOCK115	C		1	80063	_063	1	SM-C-621569	MC-6215	7			
BLOCK122	C	C	0	80063	30063	1	SM-C-652386	M1016523	5	1 OF 3	1 O - 3	1
BLOCK125	C	C	0	80063	30063	1	SM-C-652391	5M-652991	3			
BLOCK128	C	C	0	80063	30063	1	SM-C-652482	5M-9652-82	4			
BLOCK131	C		1	80063		5	SM-C-621535		11			
BLOCK136	D		1	56540	5-540	1	1041001	_0_1001	2	1 OF 2	1 6-2	2
BLOCK183	E		1	58853		5						
BLOCK198	E		1	80063		5	SC-E-35215		10			
D005R229	C	C	0	80063	30063	1	SM-C-772101	772101	5	1 OF 2	1 OF 2	0
D005R230	C		1	80063	30063	1	SM-C-772101		11	2	2	0
D005R232	C		1	80063	30063	1	SM-C-773163	3163	7	2	2	0
D005R241	C		1	80063	30063	1	SM-C-773509	5M-C-7-3509	2	1 OF 2	1 0 - 2	1
D005R242	C	C	0	80063	80063	0	SM-C-773509	5M-C-7-3509	2	2	2	0
D005R246	C	C	0	80063		5	SM-C-808812	M6-0	11	1 OF 3	1 OF 3	0
D005R247	C		1	80063		5	SM-C-808812		11			
D005R282	E		1	18876	88-6	2	1022567	1022567	0			
D005R294	C	C	0	18876	76	3	10236719	1023679	1	1 OF 1	1 OF 1	0
D005R299	F		1	55717		5	10250675		8			
D005R300	F		1	55717		5	10250675		8			
D005R341	E		1	18876		5	11070433		8			
D005R342	E	E	0	18876	18876	0	11070573	1170573	0	1 OF 1	1 - - 1	2

VisionShape Data Set 2 Test Results

D005R343	A		1	18876	18876	0	CP11070573		10	1 OF 21	1	4
D005R344	A		1	18876	18876	0	CP11070573	107053	3			
D005R385	A		1	18876		5	EC 11070573		10			
D005R394	A		1	18876		5	EOI 11070573	10-1070573	5	1 OF 22	1 OF	2
D005R458	D		1	67346		5	481-200005	481-200005	0	2	2	0
D005R472	A		1	67346		5	481-200334		10			
D005R473	A	A	0	67346	67346	0	481-200334	481-200334	0			
D005R499	C	C	0	18876	76	3	9130357	9130357	0			
Total			29			133			260			33
							Total Char. Errors	455				
							Total Characters	799				
							% Char. Correct	43%				
							Total Field Errors	150				
							Total Field	188				
							% Fields Correct	20%				

MCC Data Set 3 Test Results

	Original	Recognized		Original	Recognized		Original	Recognized		Original	Recognized	
	SIZE	SIZE	Error	CAGE #	CAGE #	Error	DRAWING #	DRAWING #	Error	Sheet	Sheet	Error
block001	A	A	0	97942	9794	1	584R012	D84R01	1	4		1
block021	B	B	0	56540	5654	1	1071010	IO7IOIO	0	1 OF 1	1 CM 1	2
block022	B	B	0	63395	63S95	1	206803-00	2O6HO3-OO	1	1 OF 1	I66I	2
block027	A	A	0	25500	255ID	2	3100109-007	3IOOIO9-OO7	0	1 OF 79	IOFIP	2
block044	B	B	0	80063	SOO63	1	SM-B-389801	JMBS88WOO	6	1 OF 3	ICF3	2
block047	B	B	0	80063	OO63	1	SM-B-389809	SMNB3O8CO3	5			
block051	B	B	0	80063	8OO63	0	SM-B-389853	SM6836985	4			
block052	B	8	1	80063	8OO63	0	SM-B-389853	SM.8-38OF53	3			
block060	B	B	0	80063	8OO63	0	SM-B-389917	JM68-38997	4			
block079	B	B	0	80063	8OO63	0	SM-B-389801	JM46L6O8OI	7	3	9	1
block086	D	D	0	19204	X92O4	1	11020141	IIO2OI4I	0	1 OF 1	I_OF_I	0
block088	C	C	0	80063	8OO63	0	SC-C-609601	S6-C-6O96OI	1			
block105	C	C	0	80063	8OO63	0	SM-C-563457	SM-C-563457	0			
block106	C	C	0	80063	8OO63	0	SM-C-604977	SMO-C-8O497	1			
block119	C	C	0	80063	8OO63	0	SM-C-652013	SM6CH652OI3	2	2F	2F	0
block134	D	D	0	56540	5654O	0	1041001	IO4IOOI	0	1 OF 2	I_OE_2	1
block156	D	D	0	80063	8OO63	0	SM-D-422468	SM-D-A22488	2	1 OF 7		4
d001r130	C	C	0	19204	I92O4	0	11010483	IIOIO483	0	1 OF 1	I_OE__I	1
d003r130	C	C	0	19204	I92O4	0	11010483	IIOIO483	0	1 OF 1	I_6E__I	2
d003r133	D	D	0	19204	X92O4	1	11020141	IIO2OI4I	0	1 OF 1	I__OF_I	0
d004r273	A	A	0	80063	8OO63	0	SM-A-773492	SM-A-773492	0	1 OF 4	I_OF_A_	1
d004r280	A	A	0	80063	8OO6	1	SM-A-773492	SM-A-773AO2	2	1 OF 4	I_OF_A_	1
d004r330	D	D	0	18876	I8876	0	10215638	IO2I563	1	1 OF 1	I_OE_I	1
d005r229	C	C	0	80063	8OO63	0	SM-C-772101	SN-C-772IOI	1	1 OF 2	I_OF_2	0
d008r003	A	A	0	19200	I92OO	0	12714307	I27I43O7	0	2	2	0
d008r008	C	C	0	19200	I92OO	0	12714417	I27I44I7	0			
d008r053	C	C	0	19200	IS2OO	1	19203200	I29O32OO	0			
d008r068	C	C	0	19200	IO2O	2	12911950	I29II95	0			
d008r255	C	C	0	19200	I92OO	0	12912209	I29I22O9	0			
d008r334	A	A	0	19200	I92OO	0	12912254	I2OI2254	0	1 OF 5	IOI5	1
d009r002.	C	C	0	19200	I92OO	0	12913746	I29_I3_7468	0			
d009r020	C	Z	1	19200	I92OO	0	12913746	I29_I3_T46O8	1			
d009r029	E	D	0	19200	I92O	1	12916786	I29I6786	0	1 OF 2	I_OF	1
d009r032	C	C	0	19200	I92O	1	12918103	I29I8IO	3			
d009r100	B	B	0	19205	I92O5	0	5009274	5OO927	1	1 OF 1	OF	2
d009r102	B	B	0	19205	IO2O5	1	5013565	5OI356	1	1 OF 1	I_OF	1
d009r104	B	B	0	19205	I92O5	0	5013611	5OI36II	0	1 OF 1		4

d009r115	A	A	0	19204	I92O4	0	5140269	5I4O269	0			
d009r149	B	B	0	19204	I92OA	1	7161256	7I6I256	0	1 OF 1	I	3
d009r150	B	B	0	19204	392O4	1	7161257	7I63257	0	1 OF 1	I_OF_I	0
d009r155	B	B	0	19205	_I92O5_	0	7269057	7_269O57	0	1 OF 1	_OF	2
d009r157	C		1	19205		5	7269145		7	1 OF 1		4
d009r174	C	C	0	19200	I92OO	0	7660418	766O4I8	0			
d009r175	C	L	1	19200	I92OO	0	7660469	766O469	0			
d009r189	B	B	0	19207	I92O7	0	7953776	7953776	0			
d009r240	C	C	0	19200	I92OO	0	8615920	86I592O	0			
d010r045	A	A	0	19200	S92ORO	1	12710085	I27IOO85	0	1 OF 17	IF_I7	2
d011r010	C	C	0	78286	78286	0	64070-85009	64OO-55OOO	3	2 OF	2_N_	3
d011r379	C	C	0	80063	8OO63	0	SM-C-772101	SN-C-772IOI	1	1 OF 2	I_OF_2	0
d011r420	C	C	0	18876	I8876	0	10210438	IO2IOO38	0	1 OF 1	IOF_I	0
d013r133	D	D	0	19204	X92O4	1	11020141	IIO2OI4I	0	1 OF 1	_I__OF_I_	0
d015r008	B	B	0	19204	I92O4	0	12007439	I2OO743	1	1 OF 1		4
d015r021	C	C	0	19204	S92O4	1	12007815	I2OO78I5	0			
d015r024	C	C	0	19204	392O4	1	12007820	I2OO7_82O	0			
d015r034	B	B	0	19204	I92O4	0	12007852	I2OO7852	0			
d015r036	C	C	0	19204	S92O4	1	12007854	I2OO7854	0			
d015r039	C	C	0	19200	I92OO	0	12912388	I29I238	1			
d015r040	F	F	0	19204	DIS2O4	2	12007855	I2O_O_7_855	0	2 OF 4	2_PI4	2
d015r042	F	F	0	19204	I92O4	0	12007855	I2OO7855	0	3 OF 4	3_OI4	1
d015r043	F	F	0	19204	I92OA	1	12007855	I2OO7_855	0	4 OF 4	O_O7_AA	3
d015r049	C	C	0	19200	I92OO	0	12913744	I29I3_I444	1			
d015r050	C	C	0	19200	I92OO	0	12913745	I29_I3I45	0			
d015r051	C	C	0	19204	S92O4	1	12007857	6O6E7	7			
d015r063	C	C	0	19200	I92OO	0	12913805	I29I38LO	2			
d015r064	C	C	0	19204	S92O4	1	12007863	I2OO7863	0			
d015r074	C	C	0	81361	3SEC	4	C123-1-55	C/23/55	4			
d015r080	B	B	0	81361	8I36I	0	B123-1-62	8/23-I-62	2			
d015r081	C	C	0	81361	8I36I	0	C123-1-63	C23-I-C63	1			
d015r083	B	S	1	81361	TS8T	5	B123-1-66	BI23-I-CCC	2			
d015r085	C	C	0	81631	8I36I	0	C123-1-68	CI23-I-G8	1			
d015r086	B	B	0	81361	7D3ET	4	B123-1-69	BI23-I-C8P	2			
d015r087	C	C	0	81361	8I36I	0	C123-1-70	C23-IIO_	3			
d015r091	D	D	0	81361	8I36I	0	D123-1-74	--G-8-NS--SSNS	9			
d015r095	A	A	0	81361	8I36I	0	DL123-1-801	DL_I23-I-8OI	0	6 OF 9	6__O_S	2
d015r135	B	B	0	81361	8I36I	0	B123-1-824	BI23-I-82O	1			
d015r260	E	E	0	81361	8I36	1	136-27-261	I3627-26I	1	1 OF 1	IOTI	1

MCC Data Set 3 Test Results

d015r261	B	B	0	81361	8I36I	0	PL 136-27-261	PL_S6N.	9	1 OF 1	IOE_I	1
d015r263	E	E	0	81361	8I36I	0	136-27-262	I36-27262	1	2 OF 2	2F2	1
d015r267	B	8	1	81361	8I36I	0	136-27-265	I36227266	3	1 OF 1	IOF_I	0
d015r282	C	C	0	81361	8I36I	0	C136-29-1	CI36-29-I	0			
d015r298	C	C	0	81361	8I36	0	C136-41-194	DI36-4I-O94	1			
d015r299	B	B	0	81361	8I36I	0	136-41-1951	I36-4II95I	1	1 OF 1	I_OE	2
d015r327	B	8	1	81361	8I36I	0	PL-136-41-1968	PII36-4I-I968	2	2 OF 2	2_OF_2_	0
d015r420	D	D	0	81361	8I365	1	5-19-11083	5I9I_IO83	2			
d015r487	C	C	0	19204	I92O4	0	7550289	755O289	0	1 OF 1	I__OF_	1
d015r520	F	F	0	19204	I92O4	0	7551818	755I8I	1	6 OF 10	6_P_IO	1
d015r540	D	D	0	19204	I92O4	0	7551830	755I83O	0	1 OF 1	__OF_I	1
d015r587	F	F	0	19203	I92O3	0	P 9234710	688..8.	8	1 OF 2	F2	2
Total			7			48			124			66
								Total Char. Errors	245			
								Total Characters	1474			
								% Char. Correct	83%			
								Total Field Errors	119			
								Total Fields	311			
								% Field Correct	62%			

Nestor Data Set 3 Test Results

	Original	Recognized		Original	Recognized		Original	Recognized		Original	Recognized	
	SIZE	SIZE	Error	CAGE #	CAGE #	Error	DRAWING #	DRAWING #	Error	Sheet	Sheet	Error
block001	A	A	0	97942	97942	0	584R012	584R012	0	4	4	0
block021	B	B	0	56540	56540	0	1071010	1071010	0	1 OF 1		4
block022	B	B	0	63395	63395	0	206803-00	20630B-LD	2	1 OF 1		4
block027	A	A	0	25500	A500	2	3100109-007	3100109-007	0	1 OF 79	LOF79	1
block044	B	B	0	80063		5	SM-B-389801	JD-2EJ69G0/	11	1 OF 3	/OF3	1
block047	B	B	0	80063	8QB	4	SM-B-389809		11			
block051	B	B	0	80063	EOEIOQG	5	SM-B-389853	3DB-3693L3	7			
block052	B	B	0	80063	3EIOMW	5	SM-B-389853	3DPG-95393	10			
block060	B	B	0	80063	LEIPW-	5	SM-B-389917	JV-3-L619	8			
block079	B	B	0	80063	4IIVD	5	SM-B-389801	JD-F-J69D0/	7	3		1
block086	D	D	0	19204	19204	0	11020141		8	1 OF 1		4
block088	C	C	0	80063	80063	0	SC-C-609601	SCR-60960N	8			
block105	C	C	0	80063	80063	0	SM-C-563457	SM-CE563457	9			
block106	C	C	0	80063	80063	0	SM-C-604977	U-C-604977	9			
block119	C	C	0	80063	80063	0	SM-C-652013	U-CS6	10	2F	2F	0
block134	D	D	0	56540	56540	0	1041001	T041OO1	1	1 OF 2	1 OF 1	1
block156	D	D	0	80063	80063	0	SM-D-422468	SM-D-A224Q8	8	1 OF 7	1 7	2
d001r130	C	C	0	19204	19204	0	11010483	110N0483	1	1 OF 1	8F1	2
d003r130	C	C	0	19204	192M	2	11010483	110N0483	1	1 OF 1	ORT	3
d003r133	D	D	0	19204	19204	0	11020141		8	1 OF 1		4
d004r273	A	A	0	80063	80063	0	SM-A-773492	SM-A-773492	0	1 OF 4	1OF4	0
d004r280	A	A	0	80063	80063	0	SM-A-773492	SM-AE773492	1	1 OF 4	1OF4	0
d004r330	D	D	0	18876	18876	0	10215638	10215638	0	1 OF 1		4
d005r229	C	C	0	80063	80063	0	SM-C-772101	SM-C-77210-	1	1 OF 2	1 OF 2	0
d008r003	A	A	0	19200	19200	0	12714307	1 7143 7	2	2	2	0
d008r008	C	C	0	19200	19200	0	12714417	27144 7	2			
d008r053	C	C	0	19200	19200	0	19203200	19 32	4			
d008r068	C	6	1	19200	19200	0	12911950	1ZE11 50	3			
d008r255	C	C	0	19200	192Q	2	12912209	1211120Q	3			
d008r334	A	A	0	19200	19200	0	12912254	129122M	2	1 OF 5	1M5	2
d009r002.	C	C	0	19200	19200	0	12913746	1 13 4	4			
d009r020	C	C	0	19200	192M	2	12913746	1 13 4	4			
d009r029	E	I	1	19200	112	3	12916786		8	1 OF 2	1OR2	1
d009r032	C	Y	1	19200		5	12918103		8			
d009r100	B	B	0	19205	19203	1	5009274	5009274	0	1 OF 1	1OF1	0
d009r102	B	B	0	19205	10M5	3	5013565	5013565	0	1 OF 1	1OF1	0
d009r104	B	B	0	19205	19205	0	5013611	50N361P	2	1 OF 1	1OFT	10

Nestor Data Set 3 Test Results

d009r115	A	A	0	19204	49204	1	5140269	5140269	0			
d009r149	B	L	1	19204	19204	0	7161256	1D111256	2	1 OF 1	1OF1	0
d009r150	B	B	0	19204	19204	0	7161257	/161257	1	1 OF 1	1OF1	0
d009r155	B	B	0	19205	19205	0	7269057	7269057	0	1 OF 1	1OE1	0
d009r157	C	C	0	19205	4920111	2	7269145	7269T45	1	1 OF 1	1OF1	0
d009r174	C	C	0	19200	1920U	1	7660418	LLPD044L3	5			
d009r175	C	C	0	19200	M9200	1	7660469	76611469	1			
d009r189	B	7	1	19207		5	7953776		7			
d009r240	C	C	0	19200	192M	2	8615920	86L592	2			
d010r045	A	A	0	19200	1921	2	12710085		8	1 OF 17	C'7	3
d011r010	C	C	0	78286	78286	0	64070-85009	64 70- 9	5	2 OF		3
d011r379	C	C	0	80063	80063	0	SM-C-772101	SM-C77210-	2	1 OF 2	1OF2	0
d011r420	C	C	0	18876	18876	0	10210438	10210438	0	1 OF 1	OF1	1
d013r133	D	D	0	19204	19204	0	11020141		8	1 OF 1	1OF1	0
d015r008	B	B	0	19204	19204	0	12007439	12007439	0	1 OF 1	1O2T	2
d015r021	C	C	0	19204	19204	0	12007815	12007815	0			
d015r024	C	C	0	19204	N9204	1	12007820	12007820	0			
d015r034	B	B	0	19204	19204	0	12007852	12007852	0			
d015r036	C	C	0	19204	19204	0	12007854	12007854	0			
d015r039	C	C	0	19200	19200	0	12912388	12G12388	1			
d015r040	F	F	0	19204	1G204	1	12007855	12007855	0	2 OF 4	2OE4	1
d015r042	F	F	0	19204	10920	2	12007855	N2007855	1	3 OF 4	3OE4	1
d015r043	F	F	0	19204	19204	0	12007855	12007855	0	4 OF 4	4OA4	1
d015r049	C	C	0	19200	192W	2	12913744	11T13S44	2			
d015r050	C	C	0	19200	192M	2	12913745		8			
d015r051	C	C	0	19204	19204	0	12007857	12007857	0			
d015r063	C	C	0	19200	192W	2	12913805		8			
d015r064	C	C	0	19204	N9204	1	12007863	12007863	0			
d015r074	C	C	0	81361	81361	0	C123-1-55		9			
d015r080	B	B	0	81361	81361	0	B123-1-62	B 23- -6G	3			
d015r081	C	C	0	81361	81361	0	C123-1-63	C 24- -CE	7			
d015r083	B	Q	1	81361	81361	0	B123-1-66	B 23- -C0	7			
d015r085	C	C	0	81631	81631	0	C123-1-68	CL23ST-E8	5			
d015r086	B	B	0	81361	81631	0	B123-1-69	BL2B-L-Q9	4			
d015r087	C	L	1	81361	81631	0	C123-1-70	C 23- -7	3			
d015r091	D	D	0	81361		5	D123-1-74		9			
d015r095	A	A	0	81361	81M1	2	DL123-1-801	DLLT6	9	6 OF 9	8OT9	1
d015r135	B	B	0	81361	81361	0	B123-1-824	B123-1-824	0			
d015r260	E	E	0	81361	81361	0	136-27-261	436-27-26	2	1 OF 1	1OF1	0

Nestor Data Set 3 Test Results

d015r261	B	B	0	81361	8Z361	1	PL 136-27-261	PL 136-27-261	1	1 OF 1	1T1	2
d015r263	E	E	0	81361	81361	0	136-27-262	136-17-261	1	2 OF 2	2OF2	0
d015r267	B	B	0	81361	81361	0	136-27-265	136-27-265	0	1 OF 1	1OE1	1
d015r282	C	C	0	81361	81361	0	C136-29-1	C136-29-1	0			
d015r298	C	L	0	81361	6138	3	C136-41-194	BLL-4- J4	8			
d015r299	B	B	0	81361	B1661	2	136-41-1951	LL-4L-LLL15L	7	1 OF 1		4
d015r327	B	B	0	81361		5	PL-136-41-1968	PL-L6-4-LLL8	6	2 OF 2	2 OF 2	0
d015r420	D	2	1	81361	81361	0	5-19-11083		10			
d015r487	C	C	0	19204	19204	0	7550289	7550289	0	1 OF 1	1OF1	0
d015r520	F	F	0	19204	19204	0	7551818	7551818	0	6 OF 10	6OE10	1
d015r540	D	D	0	19204	19204	0	7551830	7551830	0	1 OF 1	1OF1	0
d015r587	F	F	0	19203	19203	0	P 9234710	P9234710	0	1 OF 2	2	3
Total			8			92			316			68
								Total Char. Errors	484			
								Total Characters	1474			
								% Char. Correct	67%			
								Total Field Errors	134			
								Total Fields	311			
								% Field Correct	57%			

NTI Data Set 3 Test Results

	Original	Recognized		Original	Recognized		Original	Recognized		Original	Recognized	
	SIZE	SIZE	Error	CAGE #	CAGE #	Error	DRAWING #	DRAWING #	Error	Sheet	Sheet	Error
BLOCK001	A	A	0	97942	97942	0	584R012	584R012	0			
BLOCK021	B	B	0	56540	56540	0	1071010	1071010	0	1 OF 1	1 GF 1	1
BLOCK022	B	B	0	63395	63395	0	206803-00	20G80300	1	1 OF 1	1 OF 1	0
BLOCK027	A	A	0	25500	X5BD	4	31001109-007	3100109-007	0	1 OF 79	1OF 79	0
BLOCK086	D	D	0	19204	19204	0	11020141	11020141	0	1 OF 1	1 W1	2
BLOCK044	B	B	0	80063	80063	0	SM-B-389801	3M80S801	6	1 OF 3	1 OF 3	0
BLOCK047	B	B	0	80063	80063	0	SM-B-389809	M&3&005	8			
BLOCK051	B	B	0	80063	80063	0	SM-B-389853	SMB383853	3			
BLOCK052	B	B	0	80063	80063	0	SM-B-389853	SMB389853	2			
BLOCK060	B	B	0	80063	80063	0	SM-B-389917	SMB-389917	1			
BLOCK079	B	B	0	80063	80063	0	SM-B-389801	SM&389801	3			
BLOCK088	C	C	0	80063	80063	0	SC-C-609601	SC2-609601	2			
BLOCK105	C	C	0	80063	80063	0	SM-C-563457	SM-C-563457	0			
BLOCK106	C	C	0	80063	80063	0	SM-C-604977	SM-C-604977	0			
BLOCK119	C	C	0	80063	80063	0	SM-C-652013	SWC0652013	3	2F	2F	0
BLOCK134	D	D	0	56540	56540	0	1041001	1041001	0	1 OF 2	1OF 2	0
BLOCK156	D	D	0	80063	80063	0	SM-D-422468	SM-D-422468	0	1 OF 7	1 OF 7	0
D001R130	C	C	0	19204	19204	0	11010483	1101483	0	1 OF 1	1 W 1	2
D003R130	C	C	0	19204	19204	0	11010483	1101483	0	1 OF 1	1 OF 1	0
D003R133	D	D	0	19204	19204	0	11020141	11020141	0	1 OF 1	1 OF 1	0
D004R273	A	A	0	80063	80063	0	SM-A-773492	SM-A-773492	0	1 OF 4	1 OF 4	0
D004R280	A	A	0	80063	80063	0	SM-A-773492	SM-AH773492	1	1 OF 4	1 OF 4	0
D004R330	D	D	0	18876	18876	0	10215638	10215638	0	1 OF 1	1 OF 1	0
D005R229	C	C	0	80063	80063	0	SM-C-772101	SM-C-772101	0	1 OF 2	1 OF2	0
D008R003	A	A	0	19200	19200	0	12714307	12714307	0	2	2	0
D008R008	C	C	0	19200	19200	0	12714417	12714417	0			
D008R053	C		1	19200	19200	0	12903200	12903200	0			
D008R068	C	C	0	19200	19200	0	12911950	12911950	0			
D008R255	C	C	0	19200	192W	2	12912209	12912209	0			
D008R334	A	A	0	19200	19200	0	12912254	12912254	0	1 OF 5	1 OT 5	1
D009R002.	C	C	0	19200	19200	0	12913746	12913746	0			
D009R020	C	C	0	19200	192W	2	12913746	12913746	0			
D009R029	E	E	0	19200	19200	0	12916786	12916786	0	1 OF 1	1 OF 2	0
D009R032	C	C	0	19200	19200	0	12916786	12916786	0			
D009R100	B	B	0	19205	19205	0	5009274	5009274	0	1 OF 1	1 OF 1	0
D009R102	B	B	0	19205	19205	0	5013565	5013565	0	1 OF 1	1 OF 1	0
D009R104	B	B	0	19205	19205	0	5013611	5013611	0	1 OF 1	1 OF 1	0

NTI Data Set 3 Test Results

D009R115	A	A	0	19204	19204	0	5140269	5140269	0	1 OF 1	1 OF 1	0
D009R149	B	B	0	19204	19204	0	7161256	7161256	0	1 OF 1	1 OF 1	0
D009R150	B	B	0	19204	19204	0	7161257	7161257	0	1 OF 1	1 OF 1	0
D009R155	B	B	0	19205	19205	0	7269057	7269057	0	1 OF 1		4
D009R157	C	C	0	19205	19205	0	7269145	7269145	0	1 OF 1	1 OF 1	0
D009R174	C	C	0	19200	19200	0	7660418	7660418	0			
D009R175	C	C	0	19200	192G0	1	7660469	766Q469	1			
D009R189	B	B	0	19207	19207	0	7953776	7953776	0			
D009R240	C	C	0	19200	192W	2	8615920	8615920	0			
D010R045	A	A	0	19200	19200	0	12710085	12710085	0	1 OF 17	1 OF 17	0
D011R010	C	C	0	78286	78286	0	64070-85009	64070-8900S	2	2 OF	ZOF	1
D011R379	C	C	0	80063	80063	0	SM-C-772101	SM-C-772101	0	1 OF 2	1 OF 2	0
D011R420	C	C	0	18876	18876	0	10210438	10210438	0	1 OF 1	1 OF 1	0
D013R133	D	D	0	19204	19204	0	11020141	11020141	0	1 OF 1	1 OF 1	0
D015R008	B	6	1	19204	19204	0	12007439	12007439	0	1 OF 1	1 OF 1	0
D015R021	C	C	0	19204	19204	0	12007815	12007815	0			
D015R024	C	C	0	19204	19204	0	12007820	12007820	0			
D015R034	B	B	0	19204	19204	0	12007852	12007852	0			
D015R036	C	C	0	19204	19204	0	12007854	12007854	0			
D015R039	C	C	0	19200	19200	0	12912388	12912388	0			
D015R040	F	E	1	19204	19204	0	12007855	12007855	0	2 OF 4	2 OF 4	0
D015R042	F	F	0	19204	19204	0	12007855	12007855	0	3 OF 4	3 OF 4	0
D015R043	F	F	0	19204	19204	0	12007855	12007855	0	4 OF 4	4 OF 4	0
D015R049	C	C	0	19200	192W	2	112913744	112913744	0			
D015R050	C	C	0	19200	192W	2	12913745	12913745	0			
D015R051	C	C	0	19204	19204	0	12007857	12007857	0			
D015R063	C	C	0	19200	192W	2	12913805	12913805	0			
D015R064	C	C	0	19204	19204	0	12007863	12007863	0			
D015R074	C	C	0	81361	81361	0	C123-1-55	C123-1-55	0			
D015R080	B	B	0	81361	81361	0	B123-1-62	B123-1-62	0			
D015R081	C	C	0	81361	81361	0	B123-1-63	B123-1-133	2			
D015R083	B	B	0	81361	81361	0	B123-1-66	B123-1-66	0			
D015R085	C	C	0	81361	81361	0	C-123-1-68	C-123-1-68	0			
D015R086	B	B	0	81361	81361	0	B123-1-69	D123-1-69	0			
D015R087	C	C	0	81361	81361	0	C123-1-70	C123-1-70	0			
D015R091	D	D	0	81361	&361	2	B123-1-824	B123-1-824	0			
D015R095	A	A	0	81361	81361	0	DL123-1-801	DL123-1-801	0	6 OF 9	6 OF 9	0
D015R135	B	B	0	81361	81361	0	B123-1-824	B123-1-824	0			
D015R260	E	E	0	81361	81361	0	136-27-261	136-27-261	0	1 OF 1	1 OF 1	0

NTI Data Set 3 Test Results

D015R261	B	B	0	81361	81361	0	PL136-27-261	PL136-27-261	0	1 OF 1	1 OF 1	0
D015R263	E	E	0	81361	81361	0	136-27-262	136-27-262	0	2 OF 2	2 OF 2	0
D015R267	B	B	0	81361	81361	0	136-27-265	136-27-265	0	1 OF 1	1 OF 1	0
D015R282	C	C	0	81361	81361	0	C136-29-1	C136-29-1	0			
D015R298	C	C	0	81361	81361	0	C136-41-194	C136-41-194	0			
D015R299	B	B	0	81361	81361	0	136-41-1951	136-41-1951	0	1 OF 1	1 OT 1	1
D015R327	B	B	0	81361	81361	0	PL136-41-1968	PL136-41-1968	0	2 OF 2	2 OF 2	0
D015R420	D	D	0	81361	81361	0	5-19-11083	5-19-11083	0			
D015R487	C	C	0	19204	19204	0	7550289	7550289	0	1 OF 1	1 OF 1	0
D015R520	F	F	0	19204	19204	0	7551818	7551818	0	6 OF 10	6 OF 10	0
D015R540	D	D	0	19204	19204	0	7551830	7551830	0	1 OF 1	1 OF 1	0
D015R587	F	F	0	19203	19203	0	P9234710	P9234710	0	1 OF 2	1 OF 2	0
			3			19			35			12
							Total Char. Errors	69				
							Total Characters	1474				
							% Char. Correct	95%				
							Total Field Errors	31				
							Total Field	311				
							% Fields Correct	90%				

VisionShape Data Set 3 Test Results

	Original	Recognized		Original	Recognized		Original	Recognized		Original	Recognized	
	SIZE	SIZE	Error	CAGE #	CAGE #	Error	DRAWING #	DRAWING #	Error	Sheet	Sheet	Error
BLOCK001	A	L	1	97942	9~ 2	3	584R012		7			
BLOCK044	B	B	0	80063	80063	0	SM-B-389801	SM-B-38980,	1	1 0F 3		4
BLOCK047	B	B	0	80063		5	SM-B-389809	A9~~	10			
BLOCK051	B	B	0	80063	8~~~~	4	SM-B-389853	90F~3~	9			
BLOCK052	B	B	0	80063	8~~~~	4	SM-B-389853		11			
BLOCK060	B	B	0	80063	8U~~3	3	SM-B-389917	B-387	6			
BLOCK079	B	B	0	80063		5	SM-B-389801	3~~~~	10			
BLOCK088	C	C	0	80063	80063	0	SC-C-609601	S~C609~0~	5			
BLOCK105	C	C	0	80063	80063	0	SM-C-563457	S~C~~~~707	8			
BLOCK106	C	C	0	80063	80063	0	SM-C-604977	~/~~~0~	10			
BLOCK119	C		1	80063	6~	0	SM-C-652013	~0~100@	9	2F	2	1
BLOCK134	D		1	56540	5040	3	1041001	0	6	1 OF 2		4
BLOCK156	D		1	80063	80063	0	SM-D-422468	~~~D064~2~~	8	1 OF 7		4
D001R130	C	U	1	19204	19E~4	2	11010483	11010481	1	1 OF 1	1~1	2
D003R130	C	C	0	19204	19204	0	11010483	1101483	0	1 OF 1	1 OF 1	0
D004R273	A	L	1	80063	80063	0	SM-A-773492	S~~~379~~	7	1 OF 4		4
D008R053	C	C	0	19200	19200	0	12903200	12903200	0			
D008R255	C	L	1	19200	19900	1	12912209	129122	2			
D008R334	A	L	1	19200	19900	1	12912254	129122	2	1 OF 5	1	3
D009R100	B	B	0	19205	1920	1	5009274	||009274	1	1 OF 1	161	1
D009R102	B	B	0	19205	19205	0	5013565	5013565	0	1 OF 1		4
D009R155	B	B	0	19205	19205	0	7269057	7269057	0	1 0F 1		4
D011R379	C	C	0	80063	80063	0	SM-C-772101	S~C---~~|0|	7	1 OF 2		4
D015R081	C		1	81361	81361	0	B123-1-63	B/23/1	5			
D015R282	C		1	81361	81161	1	C136-29-1	C11~491	6			
D015R299	B		1	81361	~~36~1	0	136-41-1951	1@167119	9	1 OF 1		4
Total			11			33			140			39
							Total Char. Error	223				
							Total Characters	451				
							% Char. Correct	51%				
							Total Field Errors	57				
							Total Field	91				
							% Fields Correct	37%				

APPENDIX D
CADA IDENTIFICATION RECOGNITION TEST REQUIREMENTS SPECIFICATION

1 CHARACTER STRING IDENTIFICATION PROCESSING DESCRIPTION

Character String Identification Processing is a subtask of the Computer Aided Data Acceptance (CADA) task for the CALS Technology Center. Character String Identification Processing identifies each character string (regardless of fonts, block hand-printed scripts; character size is from 20x20 pixels to 200x200 pixels) in an engineering drawing, with possible background noises, such as lines and boxes, in the input image file. The input is an image file in TIFF format. The output is a list of text strings as it was originally grouped. The text string may contain mixed alphabetical characters as well as numerical characters. Characters to be recognized will consist of at least all upper case alpha, numeric letters, slash sign "/", left and right parenthesis "(", ")" and dash sign "-". There will be no exact forms to be defined, even through the Title area of engineering drawings may look like a form.

A software callable library and an API (Application Program Interface) will be delivered for CADA acceptance testing. The system will also include a Vendor Training Utility Tool . The Vendor will support the installation of the software package and provide support in using the Training Tools sufficient to enable the performance of the evaluation test through March1, 1992.

The API will include all functions necessary to process CADA ID recognition. The CADA ID recognition function is described in Section 3.0, Processing. A preliminary set of API will be provided by the Vendor and approved no later than one week after acceptance of the purchase order. The functionality described within the attachment supersede API in the case of any conflicts between the two. Any changes to the API specification shall be approved. A final API specification will be delivered with the software package.

2 INPUT

Input to the character string processing is an image file in TIFF format. The text layout is in a free format. The image may consist of single characters, text strings, lines and boxes, and noises when it is digitized. An example of the Title area image is illustrated in Figure 1.

The government will provide a suite of engineering drawing data that the Vendor shall utilize for the purpose of training of neural networks.

3 TEXT STRING RECOGNITION PROCESSING

The functional processing capability of this package is to isolate and recognize each text field in the image provided. The image to be analyzed may contain single characters, text strings, lines and boxes, and some noises when it was digitized. Text strings may contain machine-printed, as well as hand-printed letters of different sizes and fonts. A character is recognized if the recognition confidence level computed by the recognition engine has passed the input threshold value.

If there are boxes in the image file, the text strings recognized are grouped and reported by box. Text is arranged from left to right and top to bottom order in the output list. A vertical bar "|" is used as a delimiter, separating text strings for the different boxes. The associated confidence level of each character recognized will be provided.

3.1 Second Choice of recognition for Each Character

For each character to be recognized, there is a second choice for the recognition. This process is very similar to the processing defined in the above section, except that the characters with lower recognition confidence level will be put in the output. The calculated confidence level for each second choice is reported as well.

3.2 Pre-processing (PP)

This process is to identify all text string areas separated by a structure. The coordinates of the text image area is identified by the preprocessing function so that the text strings can be extracted and send to a character recognition engine.

4 OUTPUT

The output of the package is described in two parts: hard copy print out and application program interface.

4.1 Character Recognition Hard Copy Print Out

The output for the recognized characters consists two major parts: a list of characters of primary choice and a list of characters of secondary choice. Each list is a string of recognized text. Each list is also associated with an array of confidence level percentage values for each character. Each list of the recognized text strings is arranged from left to right and top to bottom order in the output list. For example, if the input file is as defined in figure 1, the output string for the first choice recognized by a good system will be:

PRODUCT SPECIFICATION MICROCIRCUITS, DIGITAL|3-73|SIZE A|FSCM NO. NO. 25500|DWG NO. 3100109-007|SCALE NONE|SHEET 1 OF 79

An array of confidence level percentage value for each character is arranged in the same sequence as the characters in the text list. The corresponding output array for the recognition confidence level of the above text string has a length of 101 entries (one confidence level entry for each character recognized).

4.2 Preprocessing

The output of the preprocessing is a list of X,Y coordinates of the upper-left and lower-right corners of the identified rectangular boxes as well as the text images areas within each rectangular box.

4.3 Application Program Interface (API)

The title block processing is invoked by calling the routine ID_processing. Calling this function will initiate processing of a title block. This function will return an integer value. A return value of zero will indicate no error, non-zero returns will indicate an error. A table of possible error return values and their associated meanings will be supplied to Accurate at software delivery. The routine provided will use the following API:

```
int ID_process (data_file_name, block_data)
char *data_file_name;
TITLEBLOCK_DATA *block_data;
```

The input to ID_Process function will consist of:

data_file_name: A pointer to a string (null terminated) containing the name of the TIFF file that contains the title block image. If the file is not in the current working directory, the full pathname should be provided.

The outputs of the ID_Process function will consist of:

block_data: A pointer to a data structure that will contain the recognition results of the title block processing. The data interested in a title block consists of rectangular boxes, the texts in each box, and text strings not in any box. The block_data structure is a "C" data structure defined as follows:

```
typedef struct    title_block_data
{

intn_box_fields;    /* number of boxes returned for this block */
intn_box_fields_allocated;
BOX_FIELD*box_fields; /* points to box-field */

intn_text_fields;    /* number of fields returned for this block
 not in any box */
intn_text_fields_allocated;
```

TEXT_FIELD*text_fields;

}TITLE_BLOCK_DATA

typedef struct box_fields
inttlx, tly, brx, bry; /* location of the box */
intn_text_fields; /* number of text fields returned for this box */
int_text_fields_allocated;
TEXT_FIELD*text_fields;

BOX_FIELDS

the TEXT_FIELDS type is defined as follows:
typedef struct text_field
{
inttlx, tly, brx, bry;/* location of text field in TIFF image */intr_char_results;/* number of chars in this text
field */
intn-chars_results_allocated;
CHAR_RESULTS*char_results;
}TEXT_FIELD

The CHAR_RESULTS type is defined as follows:

typedef struct char_results

inttlx,tly,brx,bry;/* location of character bounding box
with respect to text_field */
charchar_class[2];/* first two choices of recognized class
of character */
intconfidence[2];/* confidence of each choice */
}CHAR_RESULTS

5 PREACCEPTANCE AND ACCEPTANCE TEST

5.1 Preacceptance Test

Preacceptance tests are performed by the Vendor at their facility before the system to be evaluated is delivered. The Vendor shall, as a minimum, demonstrate the system by recognizing all text strings for five input files of the Title area cropped from the entire engineering drawing image.

5.2 Acceptance Test

Acceptance testing was performed at the end of the evaluation period, on or before March 1, 1992. The input to the acceptance test utilizes Title area images of a similar format layout to that used in the Preacceptance test, and with the equivalent image quality. The number of such images for the acceptance test is estimated around 5000. The accuracy of the delivered system is at least at 90% level for the primary choice.

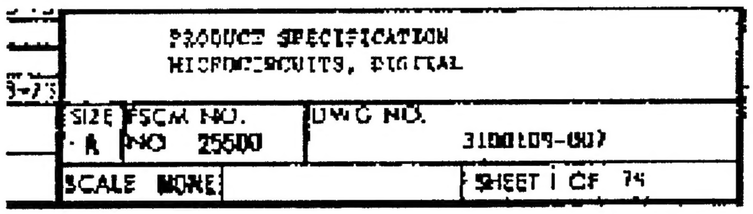

Figure D-1. Sample Input Image